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HOMELAND SECURITY DIVISION
Michigan Department of State Police

Michigan Hazard Mitigation Plan

(Updated March 2014 edition)

Reducing hazard risks and vulnerabilities through education, planning, physical improvements, early warning, and coordination of programs and resources.

Prepared by:

Emergency Management and Homeland Security Division
Michigan Department of State Police

And

The Michigan Citizen-Community Emergency Response Coordinating Council

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Michigan Hazard Mitigation Plan

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Official Promulgation Letter – Department of State Police

MICHIGAN HAZARD MITIGATION PLAN

This plan, developed and maintained pursuant to 1976 PA 390, as amended, and the federal Disaster Mitigation Act of 2000 (PL 106-390) and its implementing regulations found at 44 CFR Part 201, is hereby adopted for the State of Michigan. All participating state departments and agencies will work in conjunction with the Michigan Citizen-Community Emergency Response Coordinating Council (MCCERCC) and the Michigan Department of State Police / Emergency Management and Homeland Security Division (MSP/EMHSD) to implement those goals and objectives contained in the plan that are applicable to their respective department or agency. In addition, the State of Michigan will, in accordance with 44 CFR 13.11 c, comply with all applicable Federal statutes and regulations in effect with respect to the periods for which it receives grant funding for hazard mitigation. Further, in accordance with 44 CFR 13.11 d, the State of Michigan agrees to amend this plan whenever necessary to reflect new or revised federal statutes or regulations or material changes in any state law, organization, policy or state department or agency operation.

Chris A. Kelenske / CAPT

Capt. Chris A. Kelenske, Chairperson, Michigan Citizen-Community Emergency Response Coordinating Council and Deputy State Director of Emergency Management and Homeland Security

4/15/14
Date

Col. Kriste Kibbey Etue

Col. Kriste Kibbey Etue, State Director of Emergency Management and Homeland Security

4/16/14
Date

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Official Promulgation Letter – Governor's Office

MICHIGAN HAZARD MITIGATION PLAN

This plan, having been approved and adopted by the Michigan Citizen-Community Emergency Response Coordinating Council (MCCERCC) and the State Director of Emergency Management and Homeland Security (Colonel Kriste Kibbey Etue) and Deputy State Director of Emergency Management and Homeland Security (Captain Chris A. Kelenske), is hereby officially adopted for the State of Michigan in accordance with the federal Disaster Mitigation Act of 2000 (PL 106-390) and its implementing regulations found at 44 CFR Part 201.

Rick Snyder, Governor

4/17/2014
Date

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Michigan Hazard Mitigation Plan: Background Information

Introduction to Hazard Mitigation

What is Hazard Mitigation?

Hazard mitigation is defined as any action taken before, during, or after a disaster or emergency to permanently eliminate or reduce the long-term risk to human life and property from natural, technological and human-related hazards. It is an essential element of emergency management, along with preparedness, response and recovery. When successful, hazard mitigation will lessen the need for a community to respond to subsequent hazard events; that is, incidents will remain incidents and not become disasters.

State Government Role

Hazard mitigation strives to reduce the impact of hazards on people and property through the coordination of resources, programs, initiatives and authorities. State government has a vital coordinating role to play in this effort. Laws and processes governing the use of land and development of property originate at the state level. In addition, state agencies administer a wide variety of programs that affect – either directly or indirectly – the development and use of land. For these reasons, state government is the logical level of origination for hazard mitigation measures that have statewide application and/or implications.

Local Government Role

The implementation of hazard mitigation measures is inherently a local government function since that is the level at which development occurs, and most of the land use and development mechanisms available to implement hazard mitigation measures are applied at the local level. Therefore, successful implementation of a program to reduce Michigan's vulnerability to hazards will, out of necessity, be a joint cooperative effort between the state, local governments, and the private sector (since most land development is undertaken by private entities).

Coordination of Ongoing Efforts

Coordination is probably the most critical factor in a successful hazard mitigation effort or program. Many state and local agencies (as well as some private sector organizations) are already performing functions or administering programs that in some way contribute to hazard mitigation. Examples of existing, ongoing activities that promote or can contribute to hazard mitigation include but are not limited to:

- Capital improvements planning;
- Budgeting;
- Site-specific hazardous material emergency planning (through Local Emergency Planning Committees);
- Watershed management planning;
- Solid waste management planning;
- Local community planning and zoning activities;
- Regional planning;
- Transportation planning;
- Recreation planning;
- Forest management;
- Coastal zone management;
- Infrastructure design, regulation and permitting;
- Floodplain management; and
- Public facility design and construction review.

Unfortunately, coordination of these programs and activities for the purpose of achieving widespread hazard risk and vulnerability reduction is often limited, if it occurs at all.

Michigan Citizen-Community Emergency Response Coordinating Council

Before the late 1990s, the lack of a central focus and coordinating element for hazard mitigation in Michigan had long hampered the development of an effective statewide program of hazard risk and vulnerability reduction. In response to that problem, Governor John Engler signed Executive Order 1998-5 on July 29, 1998, creating the Michigan Hazard Mitigation Coordinating Council (MHMCC) to fill the void of hazard mitigation coordination at the state level. The MHMCC existed for nine years and officially met a total of 31 times. The MHMCC had many noteworthy accomplishments, the most prominent of which included:

- Selection of over 160 hazard mitigation projects, totaling in excess of $45 million in project costs, for four federal hazard mitigation grant programs. This included projects related to three federally-declared major disasters.
- Assisting in the development of Michigan Executive Directive 2001-5 (State Flood Hazard Mitigation), signed by Governor John Engler on September 11, 2001.
- Assisting in the development of the initial Michigan Hazard Mitigation Plan in 2004 (certified as federal Disaster Mitigation Act of 2000 compliant on March 23, 2005).
- Assisting in the development of Michigan's "Most Wanted Hazard Mitigation Measures" list as a component element of the Council's Annual Report of Activities to the Governor and Michigan Legislature.
- Assisting in the development of post-incident Hazard Mitigation Strategies for three federally-declared major disasters (1346-DR-MI; 1413-DR-MI; and 1527-DR-MI).
- Selection / coordination of four "Project Impact" communities in Michigan (City of Midland – 1998; Ottawa County – 1999; City of Dearborn – 2000; and Ingham County – 2001) as part of the federal Project Impact Initiative that existed from 1997 to 2002.
- Assisting in the development of a statewide repetitive flood loss reduction project (pilot effort currently ongoing in the Village of Estral Beach, Monroe County).
- Assisting in the development of a statewide local hazard mitigation planning project to develop plans covering all 83 counties.
- Assisting in the development of a statewide hazard mitigation marketing and education campaign for seven targeted professional groups.

On May 2, 2007, the MHMCC was abolished by Governor Jennifer Granholm's Executive Order 2007-18 and replaced by the new Michigan Citizen-Community Emergency Response Coordinating Council (MCCERCC). This new advisory body combines the MHMCC with the Michigan Citizen Corps Council and the Michigan Emergency Planning and Community Right-to-Know Commission (which were also abolished) to form a single entity chaired by the Department of State Police. The new Council is responsible for developing and implementing emergency response and hazard mitigation plans for the state. Executive Order 2007-18 transferred the MHMCC's hazard mitigation responsibilities intact to the new MCCERCC. The MCCERCC membership was announced on August 29, 2007, and its first meeting was held on January 29, 2008.

The MCCERCC is chaired by the Emergency Management and Homeland Security Division of the Michigan Department of State Police (MSP/EMHSD) and is composed of 19 representatives, including the Directors of (or a designee from) the Michigan Departments of State Police, Agriculture and Rural Development, Community Health, Environmental Quality, Military and Veterans Affairs, and Transportation; the State Fire Marshal; the Michigan Community Service Commission; plus 11 other representatives appointed by the Governor. Provisions in the Executive Order allow for the hiring or retention of contractors, subcontractors, advisors, consultants, and agents, as required when specific issues are addressed that require specialized expertise or technical knowledge.

Executive Order 2007-18 charges the MCCERCC with four primary hazard mitigation responsibilities:

- Assisting in the development, maintenance, and implementation of a state hazard mitigation plan.
- Assisting in the development, maintenance, and implementation of guidance and informational materials to support the hazard mitigation efforts of local and state government, and private entities.

- Soliciting, reviewing, and identifying hazard mitigation projects for funding, including but not limited to federal funding under Section 404 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act, 42 USC 5170c, and Sections 553 and 554 of the National Flood Insurance Reform Act of 1994, 42 USC 4104c and 42 USC 4014d.
- Fostering and promoting, where appropriate, hazard mitigation principles and practices within local and state government, and with the general public.

The MCCERCC committee structure includes a Hazard Mitigation Committee. The hazard mitigation committee was formed to oversee and focus on the Council's four hazard mitigation responsibilities. As described in a later section of this plan, both the committee and the council have been actively involved in the review and update of the 2014 Michigan Hazard Mitigation Plan.

Vision Statement
"To reduce, prevent, and prepare for emergencies or disasters"

Mission Statement
"To support and enhance Michigan's homeland security, community health, public safety, and all-hazards preparedness with responsible leadership and planning."

Just as the MCCERCC has assisted in maintaining, and implementing the 2008 and 2011 plans, it has helped to update the 2014 plan, and will continue to support and promote hazard mitigation concepts, principles, strategies and practices within governmental agencies and private sector organizations in Michigan. The latter can be accomplished in a variety of ways, including:

- Amendments to laws, rules, regulations, plans, and procedures;
- Changes in governmental and business practices and processes;
- Public education and awareness campaigns;
- Coordination of programs, information, initiatives and resources;
- Development of structural and non-structural projects to mitigate location-specific hazard vulnerabilities; and
- Establishment of collaborative public/private partnerships to identify, develop, and implement specific hazard mitigation opportunities for local, regional, or statewide application.

The primary advantage of the MCCERCC is that it fosters improved coordination of ideas, expertise, talent, programs, laws, rules and regulations, philosophies, and material resources. Such coordination manifests itself in many ways, including but not limited to:

- Better and faster delivery of hazard mitigation programs and services (during disaster and non-disaster times);
- Less duplication of and overlap between actions and activities;
- Improved information flow among agencies, levels of government, and between public and private entities;
- Development and implementation of multi-objective projects with fewer resources expended;
- Greater understanding of mitigation issues and concerns (issues are addressed by multiple agencies with multiple perspectives); and
- Greater cost savings to the taxpayers due to reduced future damages from disasters and reduced response and recovery costs (and due to the reasons listed above).

With the leadership provided by the MCCERCC, it is hoped that this plan will provide the structure and coordination mechanism necessary to bring together the many disparate, yet interrelated programs and activities that promote hazard mitigation to achieve an effective, meaningful hazard vulnerability reduction strategy for the state.

For more specific information about current MCCERCC membership, and Executive Order No. 2007-18, please refer to Attachment D in the back section of this plan.

Hazard Mitigation: Unlocking the Disaster Equation

Perhaps the best way to understand hazard mitigation is to first understand the nature of disasters themselves. The basic equation for a disaster is simple: **Hazards + People and Structures = Disaster.** Disasters only occur because people and structures are in harm's way. The key to preventing or limiting disaster damage and impact is to unlock and separate the key components of this equation. Controlling the hazard may be difficult or impossible (a tornado is a good example), but there are situations in which vulnerability can be effectively reduced. (See strategy numbers 2 through 4 below for more information.) Modifying the characteristics of people and structures is often easier and more effective in reducing or eliminating hazard vulnerability because these elements are more closely under our control. However, even that can be a daunting proposition at times, given the freedom of choice that Americans value and the widespread appeal of living near water, in the woods, on hillsides, or in other hazard-prone or at-risk areas.

The following are five basic hazard mitigation strategies that can reduce or prevent the harmful interaction between hazards, people, and development that results in a disaster:

Strategy #1: Modification of the Hazard

The first strategy involves modification of the hazard itself, which involves removing or eliminating the hazard, reducing its size or amount, or controlling the rate of release of the hazard. In the right circumstances, this strategy can be successful, but it is often difficult to do. Examples of this strategy include cloud seeding, slope planting to prevent erosion, and stream widening or modification to improve water flow. These measures can be cost-effective, but their application is normally limited and therefore not always as effective as other strategies in reducing or eliminating damage on a wide scale.

The four remaining mitigation strategies involve modification of the people and structures portion of the disaster equation.

Strategy #2: Segregating the Hazard

Strategy number two, segregating the hazard, attempts to *"keep the hazard away from people."* This is often accomplished in flood-prone areas through the construction of structural protection measures such as dams, levees, floodwalls, debris basins and other public works projects designed to redirect the impacts of a flood away from people and development. This strategy can be highly effective, but it can also be expensive and in some cases can cause (or exacerbate) environmental problems. Also, history has shown that structural protection measures constructed to protect one community can increase problems in other communities (e.g., levees that channel and increase the velocity of floodwaters, causing severe flooding downstream). Economics and limited effectiveness may make this a marginal strategy in many situations and locations.

Strategy #3: Preventing or Limiting Development

The third strategy involves preventing or limiting development in locations where people and development would be at risk. This approach is based on *"keeping the people away from the hazard"* and includes a variety of land use planning and development regulation tools, such as comprehensive planning, zoning, floodplain management ordinances, capital improvements planning, disclosure laws, and acquisition and relocation of hazard prone properties. This approach attempts to reduce or eliminate community hazard vulnerability through wise and prudent land use and development decision-making. When properly applied, this strategy can be highly effective in promoting safe, sustainable development.

Strategy #4: Altering Design or Construction

The fourth strategy involves alteration of the design or construction of development to make it less vulnerable to disaster damage. This strategy, commonly known as *"interacting with the hazard,"* allows the hazards to interact with human systems that have been designed and planned to withstand potentially destructive impacts. Examples of this strategy include elevating structures, employing wet and dry flood-proofing to improve flood damage resistance,

managing vegetation buffer zones in urban/wildland intermix areas, using wind bracing to improve wind damage resistance, and insulating water and sewer lines to prevent ground freeze damage. This strategy allows development in hazard prone areas, but requires that the development meet stringent disaster resistant performance criteria. In many situations, this approach balances the dual needs of enhancing a community's economic base while at the same time reducing community hazard vulnerability. History has shown that the two goals are not mutually exclusive. When careful and prudent development decisions are made that take into account the reduction of hazard vulnerabilities, the result is safe and sustainable community development.

Strategy #5: Early Warning and Public Education (overlaps with emergency management preparedness/response)
This strategy seeks to ensure that the public is aware of the hazards it faces, and that proper warning and communication systems and practices are in place to save lives and protect property. This strategy should be applied in all communities, as it is typically the last line of defense against serious disaster related injury or loss of life.

Hazard Mitigation: Corrective and Preventive
Alternatively, hazard mitigation strategies can also be grouped into two broad categories:

- **CORRECTIVE MITIGATION –** correcting past practices that have increased hazard vulnerability; and
- **PREVENTIVE MITIGATION –** preventing future problems from occurring in the first place through public education, wise decision-making, and disaster-resistant building / development practices.

The Corrective form of hazard mitigation can be expensive, resource intensive, time consuming, and sometimes only marginally effective. Structural protection measures, hazard modification, and large-scale retrofitting fall under this category. Attempting to go back and fix something that is problematic is almost always more difficult than doing it right the first time. However, when dealing with hazard prone property (i.e., structures in a floodway, floodplain or other hazard area), it is often necessary to go back and try to correct the problem in order to protect the affected community and individual property owners from future harm.

The Preventive form of hazard mitigation is desirable because it seeks to prevent future problems from occurring in the first place. Wise land use planning and building design, small-scale retrofitting, and early warning and public education fall under this category. When it comes to reducing community hazard vulnerability, the old adage "an ounce of prevention is worth a pound of cure" certainly makes sense. (Or, with hazard mitigation, perhaps it is more appropriate to say "an ounce of mitigation is worth a pound of recovery!") Doing it right the first time is almost always preferable to going back and trying to correct recurring problems at a later date. Preventive mitigation is generally easier to implement than corrective mitigation because the administrative mechanisms that guide the land development process – planning and plan review, zoning, capital improvements programming, building codes and standards, etc. – are available to every local community and only require adoption and consistent application to be highly effective in reducing or eliminating hazard vulnerability.

This plan addresses both types of hazard mitigation—an ideal hazard mitigation program will involve both types being applied in appropriate amounts, in appropriate places, in a coordinated fashion. **However, particular emphasis is placed on the preventive form of hazard mitigation, since this approach is generally more flexible and cost-effective and can significantly reduce or eliminate future hazard vulnerability.** The preventive form of hazard mitigation can help ensure that, at the very least, the state and local governments do not contribute to the increasing severity of the problem through unwise decision-making. The corrective form of hazard mitigation measures, on the other hand, are emphasized for areas that suffer recurring or particularly severe disaster damages and impacts or that offer clear hazard mitigation opportunities that can be addressed with existing resources.

Please refer to the following sections that appear later in this plan, for more specific information about mitigation alternatives, the evaluation of alternatives, and Michigan's chosen mitigation objectives for 2014: Risk and Vulnerability Assessments Section, Hazard Analysis Sections, Hazard Mitigation Tools and Measures, State Hazard Mitigation Goals and Objectives, Attachment C (Hazard Mitigation Funding Sources and Projects), Attachment E (State Flood Mitigation Plan), and Attachment F (Hazard Mitigation Strategies for Federally Declared Disasters).

Michigan's Vulnerability to Hazards

Michigan is vulnerable to a wide range of natural, technological and human-related hazards. Although Michigan is fortunate in that it is generally not susceptible to catastrophic disasters involving major earthquakes or hurricanes, it nonetheless has its share of potentially severe and/or widespread disasters and emergencies. As a relatively heavily populated state with thousands of inland lakes, hundreds of rivers and streams, over 3,200 miles of Great Lakes shoreline, numerous major manufacturing centers, frequent wind and winter storms, and lying on the northern fringe of the nation's tornado belt, Michigan experiences major disasters and emergencies on a regular basis.

The Hazard Analysis section in this document describes the state's vulnerability to more than two dozen different types of natural, technological, and human-related hazards, ranging from civil disturbances to snowstorms. Although Michigan can potentially be affected in some way by all of these hazards, several of them cause more disaster events and generally result in more damage and/or impact to affected communities than the others. (Summaries and analyses appear in the Hazard Analysis sections of this plan.)

Since 1953, Michigan has experienced 34 events that resulted in the declaration of a major disaster or emergency by the President. Since 1977, Michigan has experienced 64 events that resulted in a Governor's declaration of disaster or emergency. The majority of those declarations, at both levels, were granted for flooding, tornadoes, winter storms, or severe thunderstorms. These disasters or emergencies resulted in hundreds of millions of dollars in damage and destruction and caused tremendous disruption to the affected communities. Clearly, there is a need to focus hazard mitigation efforts on those four hazards in particular. In addition, wildfires occur with regularity across much of the state and can severely impact the safety and well being of affected communities. Local plans confirm that wildfires are significant throughout Northern Michigan, and therefore wildfire mitigation is an important priority as well. In addition to these natural hazards, FEMA is also requiring the state of Michigan to address land subsidence, coastal erosion, extreme temperatures, dam failures, earthquakes, and drought as part of this plan revision.

For a detailed analysis of these hazards, please refer to the "hazard analysis" section that forms the core of this plan. For summaries of all declared state and federal disaster and emergency declarations in Michigan, please refer to Attachment B in the back section of this document. For the text of hazard mitigation strategies stemming from recent federally-declared disasters, please refer to Attachment F, toward the end of this document.

Hazard Mitigation: National Perspective and Federal Government Role

Nationally, hazard mitigation is at a crossroads. Recent catastrophic disasters across the United States have resulted in unparalleled devastation, suffering, and economic loss. These events have suggested that certain aspects of development strategy throughout the U.S. have been on a collision course with our natural environment. Increased development in hazard prone areas has put an ever-increasing number of people and structures in harm's way, greatly exacerbating our risk and vulnerability to natural, technological, and human-related hazards. As a result, when disasters occur they increasingly cause tremendous economic, social, and physical losses to the communities and people they affect. Fortunately, Michigan's less rapid rate of development currently offers many of its communities a chance to prevent many risks in the state from increasing with time, though appropriate plans and policies. (Michigan was the only state to decline in population between the previous U.S. censuses, although this trend did not bring a halt to ongoing trends of greenfield development patterns.)

National efforts are also under way to promote resilient communities and hazard mitigation. Grant programs and updated guidance from the Federal Emergency Management Agency have supported the development of plans, nationwide. The National Mitigation Strategy, National Pre-Disaster Mitigation Plan, National Flood Insurance Program (NFIP), Flood Mitigation Assistance Program (FMAP), Hazard Mitigation Grant Program (HMGP), Pre-Disaster Mitigation Program (PDMP), and the Disaster Mitigation Act of 2000 are the most prominent of the federal government's current efforts to reduce or eliminate the nation's risk and vulnerability to hazards. FEMA's efforts are in partnership with federal agencies, the Congress, the states, local governments, academia, the private sector, and individual citizens. The approach is one that invites the participation of the whole community—public, private, non-profit, and the civil sectors.

Balancing Competing Priorities

The state of Michigan has been an active partner in hazard mitigation activities for many years, through the development and implementation of this plan and through its extensive support for the development and implementation of counterpart hazard mitigation plans at the local government level. The first phase of local plan development has come to an end as the vast majority of Michigan counties have now developed FEMA-approved local hazard mitigation plans. This was a huge step in a large proactive effort to reduce the state's risk and vulnerability to hazards. Now, many local hazard mitigation plans need to be successfully updated as part of an ongoing 5-year cycle, with each update required to pass official FEMA review. This updated Michigan Hazard Mitigation Plan provides a foundation for these proactive and sustained hazard mitigation efforts in the state of Michigan. Subsequent steps have involved the actual implementation of the hazard mitigation plans, as resources and circumstances permit. In addition to plan implementation, considerable work still needs to be done, assisted by the MCCERCC, to ensure that mitigation programs, plans, initiatives, resources, laws, rules and regulations are coordinated to work more smoothly and efficiently, and to meet state mitigation goals and objectives. Considerable work must also be done to educate the public about the benefits of mitigation and the need for a proactive, sustained hazard mitigation effort at all levels of government and within the private sector. Greater coordination between public and private agencies at all levels, and between tribal, non-profit, and academic institutions should also be promoted.

This multi-hazard, state-level hazard mitigation plan is designed to promote and achieve better coordination among agencies, maintain and enhance an evidence-based assessment and prioritization of hazard mitigation actions at all levels, and to build and sustain awareness and education about hazard risks and vulnerabilities among all stakeholders and residents in Michigan. This plan has in many ways sought a unified approach to emergency management—overcoming arbitrary or artificial distinctions between "preparedness," "prevention," "response," "recovery," and "mitigation" by taking a broader approach to hazard mitigation to emphasize any and all activities that help to protect, sustain, and improve Michigan's people, property, environment, economy, and quality of life. This design is in accordance with the standards of the Emergency Management Accreditation Program, whose full accreditation Michigan had obtained in April 2011.

Hazard Mitigation: Creating Safe, Sustainable Communities

Background Note: It must be emphasized that the focus and intent of this plan is not to encourage wholesale limits on development or in any way to usurp the authority or scope of local land use and land development decision-making. Land use decisions in Michigan, by and large, have been made by local officials based on local priorities and conditions. What this plan seeks to promote is *safe, sustainable development and communities* by integrating hazard mitigation considerations into everyday governmental and private sector business practices and processes. This in turn will help reduce injuries and loss of life, property and environmental damage, and adverse economic, social and service impacts caused by natural, technological, and human-related hazards.

To create and maintain safe, sustainable communities, **both preventive and corrective forms of hazard mitigation must occur at the state and local levels.** An example of the preventive form of hazard mitigation at the local level would be a policy requiring that all future development occur in such a way as to avoid or reduce, to the extent possible, community exposure and vulnerability to hazards. That would prevent the scope and magnitude of the problem from increasing. The corrective form of hazard mitigation therefore could be applied in those areas that already have a high degree of exposure and vulnerability to certain hazards and therefore suffer severe and/or repetitive damage as a result. Such actions would correct current problems caused by unwise and/or outdated land development patterns.

Because disasters can be particularly devastating for private businesses and industry, creating and maintaining safe, sustainable communities makes "business sense" as well. The statistics related to business losses and disasters are alarming. For example, statistics from the National Fire Protection Association (NFPA) show that 40% of organizations that suffer a major disaster of any kind go out of business within one year. A University of Minnesota study found that 93% of all businesses that lost their data centers for 10 days or more went out of business – 50% filing for bankruptcy almost immediately. A follow up study by Datapro Research found that 43% of the businesses in the University of Minnesota study never reopened, and an additional 29% went under within two years. Clearly, creating and maintaining safe, sustainable communities through the implementation of mitigation measures at the state and local government levels is in the best interests of private business and industry.

As stated previously, this plan addresses both types of hazard mitigation but emphasizes the preventive form to most efficiently and effectively keep the scope and magnitude of future problems in check.

Hazard Mitigation Plans Identify and Create Implementable Hazard Mitigation Opportunities

It must be emphasized that the hazard mitigation measures identified in this plan and in counterpart local plans are, in reality, **hazard mitigation opportunities.** Identification of a possible hazard mitigation measure does not necessarily mean that it can or even should be implemented. Implementation (and the desirability) of a hazard mitigation measure is highly dependent on a number of factors—environmental, social, economic and political. Just because a measure may reduce or eliminate the effects of a hazard does not necessarily mean that it should be implemented. There may be extenuating factors or circumstances that could or should preclude its implementation. Those decisions will be made in the local and state political arenas and in the land use and land development decision-making processes. Typically, hazard mitigation measures will be implemented if they are able to balance environmental, social, economic and political factors, and are cost-effective. It does not make sense to implement a measure that will not be supported by state and/or local officials and the citizenry, or that cannot be economically justified.

Accomplishing everything proposed in this plan will be a very tall order and will take years. Nevertheless, it is important to the future of this state that these issues be addressed, at least to some degree. Our nation, our state, our local communities and the insurance industry cannot continue to respond to and pay for increasingly large disasters. Proper application of hazard mitigation measures and strategies, coupled with wise land use and land development decision-making, can help our communities become more safe and sustainable, and our future as disaster-free as possible

The Role of the Citizen

Each citizen or resident of Michigan has a role in disasters and emergency preparedness, which can help to protect lives during a serious event. The following list of preparedness actions should be studied by each person, with a consideration of the types of hazards described throughout this document.

1. Develop an emergency plan for your household—Even an informal draft plan is a useful starting point! Consider the ways to prepare for the various hazards that could occur in your area, and the ways that would be best to respond. Do you have a way to contact and meet your family members, if something prevents you from staying in or returning to your home? Do you know the most reliable evacuation route if you have to leave your community in an evacuation?
2. Keep a supply of food and water—Consider how many days it is possible for your home or community to be without power or other utilities during a disaster event. You should always possess a supply of fresh water (e.g. in bottles) and food (which does not require refrigeration or cooking) in order to help you endure periods without your community's normal water supply, power supply, and services. In your preparation, include a consideration of the medicines that will be needed. Many emergencies cause a loss of power for 2 or 3 days, so your preparations should allow you to live independently for at least that long (preferably longer).
3. Equip your home and vehicle—At a minimum, some useful items to enable survival during a disaster would include a first aid kit, flashlight with batteries, a battery operated radio, and adequate clothing and blankets. Basic training in first aid may be vital to allow the effects of injuries and weather to be dealt with.
4. During a disaster, use your available communication devices (battery operated radios and phones) to listen for instructions from official sources, and do what you can to obey those instructions. Be prepared to change your evacuation route, for example, if you learn that your original route is unavailable. Consider various alternatives that you could evacuate to (such as friends and family who live in different areas that may be less seriously affected by the emergency).

Most of this document addresses the analysis and mitigation of hazards that could have a serious impact upon Michigan or some of its communities. However, this small section describes personal and household preparedness actions that may become more important to your safety during a disaster than governmental efforts.

Michigan Hazard Mitigation Plan: Planning Preliminaries, Preparation, Participation, and Process

Plan Purpose

This plan and the recommendations made herein are intended to provide the framework and foundation for hazard mitigation within the State of Michigan, in accordance with the planning requirements set forth in the federal Disaster Mitigation Act of 2000 (and in subsequent regulations and FEMA policies). Implementation of this plan should result in greater protection to human life, property and the environment, and less physical, economic, and social disruption to communities and residents from natural, technological and human-related hazards. The ideal end-state is complete integration of hazard mitigation activities, programs, capabilities and actions into normal, day-to-day governmental and private sector functions and business management practices, at all levels of organization, across jurisdictional boundaries, and across all phases of emergency management.

Plan Scope

This plan takes a broad perspective in examining natural hazard mitigation activities and opportunities in the state of Michigan. Special emphasis has been placed on those hazards that have actually caused or could potentially create hazardous conditions resulting in significant threats to public health, safety and welfare, and the social, economic and physical fabric of communities. The plan:

- Identifies and analyzes the primary hazards that have impacted the state, or have the potential to impact the state;
- Analyzes Michigan's vulnerability to those identified hazards in terms of the impacts upon local jurisdictions and state owned/operated critical facilities;
- Estimates potential dollar losses (where applicable) to state owned/operated critical facilities;
- Incorporates hazard mitigation into a broader framework of interagency and interdisciplinary coordination, including land use and comprehensive planning activities, homeland security and military considerations, and draws upon those broader frameworks for additional technical, theoretical, and practical knowledge within the analysis;
- Assesses the current strengths and weaknesses of hazard mitigation and emergency management capabilities and resources in Michigan;
- Achieves a greater level of integration and coordination between state and local planning documents and activities;
- Incorporates hazard mitigation into a broader framework of emergency management preparedness, response, and recovery, and draws upon that broader framework;
- Examines specific hazard mitigation measures that have been taken (and that can be considered) to address hazards in Michigan;
- Documents existing federal, state, local, quasi-public, and private programs and initiatives that directly or indirectly promote hazard mitigation; and
- Recommends both short-term and long-term hazard mitigation opportunities that the state of Michigan, local governments, private industry, non-profit agencies, and individual households should consider implementing.

Most of the measures ultimately recommended are statewide or regional in nature and application. Local hazard mitigation plans developed throughout Michigan contain strategies that are specific to many additional local agencies and sites. Potential resources and methods for implementing recommended measures are also identified. The hazard mitigation opportunities outlined in the plan were identified from a number of sources, including:

- Damage assessment information from recent disasters in Michigan and other states;
- Hazard mitigation projects funded or applied for under various federal and state mitigation programs, in Michigan and in other states;

- The Michigan Hazard Analysis (latest edition, dated July 2012);
- Local hazard analyses, hazard mitigation plans, and land use / comprehensive plans throughout Michigan;
- Disaster case studies and after-action reports from recent disasters in Michigan and other states;
- Hazard analyses and hazard mitigation plans for the adjacent states of Ohio, Indiana, Wisconsin, and the province of Ontario (Canada).
- Hazard mitigation strategy reports and Section 409 hazard mitigation plans from previous disasters in Michigan and other states;
- Hazard mitigation guidance documents, such as MSP/EMHSD Pub. 207, FEMA guidance, special studies, and other academic, theoretical, and scholarly literature and reference materials;
- Emergency management communications (e.g. Law Enforcement Information Network, E-Team, MI-CIMS, National Weather Service, Emergency Alert System) and media reports of recent emergency events or threats; and
- Specific recommendations made by federal, state and local agencies, and private industry.

Legal Authority

This plan is developed under the authority of 1976 PA 390, as amended: the Michigan Emergency Management Act. This Act and its subsequent Administrative Rules provide the Department of State Police with broad authority to carry out the emergency management activities of mitigation, preparedness, response and recovery within the state of Michigan. In addition, it empowers each state department to carry out the emergency tasks assigned to it by the Department of State Police in the Michigan Emergency Management Plan (MEMP) or other means—which include the planning, development, and implementation of hazard mitigation measures.

If a disastrous event in Michigan results in a federal major disaster declaration under Public Law 93-288 (Robert T. Stafford Disaster Relief and Emergency Assistance Act, as amended by the Disaster Mitigation Act of 2000), **this plan will serve as the state hazard mitigation plan required under Section 322 of the Act as a condition of receiving federal disaster relief assistance.**

The MHMP also provides assurances that the state will continue to comply with all applicable federal statutes and regulations during the periods for which it receives grant funding, in compliance with 44 CFR 13.11(c), and will amend its plan whenever necessary to reflect changes in state or federal laws and statutes, as required in 44 CFR 13.11(d).

Planning Process

This plan was revised from 2011 to 2014, overseen by the Emergency Management and Homeland Security Division of the Michigan State Police (MSP/EMHSD), working in conjunction with the Michigan Citizen-Community Emergency Response Coordinating Council (MCCERCC) and a wide array of other stakeholders. (A table later in this section provides a list of those stakeholders who contributed to the plan's revision.)

Initial Plan Development: Before the Disaster Mitigation Act of 2000

From a historical perspective, this plan was initially developed as a planning product under the Emergency Management Performance Grant (EMPG) from the Federal Emergency Management Agency (FEMA), and was initially approved as such by FEMA Region V on November 2, 2000 subsequent to Federal Disaster 1346-DR-MI. That plan was developed prior to the enactment of the federal Disaster Mitigation Act (DMA) of 2000 and the subsequent publication of its implementing rules in the Federal Register on February 26, 2002. The initial version of this plan followed existing federal hazard mitigation planning guidance available at the time of its development.

Significant New Planning Requirements Unveiled in the early 2000s

When DMA 2000 Interim Final Rules were published in the Federal Register on February 26, 2002, significant new planning requirements were placed upon the states and their local governments. The most important change was the requirement that states have a FEMA-approved mitigation plan in place by no later than November 1, 2004 in order to remain eligible for all non-emergency forms of federal relief assistance under the Stafford Act. In addition, the new DMA 2000 planning standards were considerably more detailed than were the standards recommended in previous

editions of federal mitigation planning guidance. As a result, the state of Michigan had to initiate a complex planning process, involving numerous individuals and agencies, in a relatively short time period in order to meet the initial November 1, 2004 plan approval deadline under DMA 2000. (Note: the November 1, 2004 deadline was later extended by FEMA to May 1, 2005, which allowed the MSP/EMHSD a bit more flexibility in completing the planning process and Michigan's plan was completed by the end of March 2005.)

Unfortunately, while that was going on there was also an enormous effort to place considerable planning, training, exercising and coordination requirements on the state in order to improve local and state capabilities to respond to and recover from terrorism and related threats in the aftermath of September 11, 2001. These new efforts caused a significant diversion of state and local agency attention, time and resources away from more traditional emergency management and hazard mitigation activities. Tight federal timelines for the various weapons of mass destruction (WMD) grants that were hastily implemented in the post-9/11 period forced the MSP/EMHSD (like other state emergency management agencies around the country) to divert significant numbers of staff to homeland security work. Therefore, completion of the initial version of this plan necessarily took a back seat to other more pressing priorities during much of 2002 and 2003. It is against that backdrop that the development of this plan to meet the DMA 2000 planning requirements began in February of 2004.

Synopsis of 2004-2005 Planning Process

The planning effort for the 2004-05 initial plan development revolved around the Michigan Hazard Mitigation Coordinating Council (MHMCC) – the state's hazard mitigation coordinating body in existence at the time. The 10-member MHMCC joined with the MSP/EMHSD and a wide array of stakeholders (refer to the 2004-05 edition for specifics) to form a large, multi-agency plan development team. The team worked for several months to develop the initial DMA 2000 hazard mitigation plan for the state of Michigan. The plan was officially adopted and formally promulgated by the MHMCC on October 19, 2004, and the State Director and Deputy State Director of Emergency Management and Homeland Security on December 15, 2004 (the two highest ranking emergency management / homeland security officials in Michigan). Governor Jennifer Granholm adopted the plan on behalf of the state of Michigan on March 4, 2005. The plan was subsequently approved by FEMA as a Standard State Hazard Mitigation Plan under the DMA 2000 on March 28, 2005.

Synopsis of 2007-2008 Planning Process

The planning effort for the 2007-08 plan revision was similar in nature to the 2004-05 process, except that staff shortages caused a focus purely upon natural hazards, and entailed a substantial reformat of the plan, to make it less cumbersome and more self-contained. What had previously been separate documents, referred to as attachments, instead had their content made a part of the main planning document, with sections called attachments now functioning more as appendices in a single document. The process was spearheaded by the lead Hazard Mitigation Planner of the MSP/EMHSD, with assistance provided by the other MSP/EMHSD staff (i.e., State Support Unit Manager / State Planner, State Hazard Mitigation Officer and Assistant State Hazard Mitigation Officer, and three planners from the Local Support Unit). The lack of an active hazard mitigation council for several months of 2007 (the MHMCC was abolished on May 2, 2007 and replaced by the new MCCERCC, which met for the first time on January 29, 2008) hampered the effort from the start. Fortunately, the MSP/EMHSD was able to contact key stakeholders and receive input through the state agency Emergency Management Coordinators and/or the subject matter experts in their respective agencies for each natural hazard addressed in the plan. The new MCCERCC membership also had the opportunity to review and comment on the various plan sections as they were revised, as did key MSP/EMHSD subject matter experts and subject matter experts from applicable federal agencies and nongovernmental organizations. Collectively, these individuals constituted the planning team for the 2008 MHMP revision. Due to these many challenges, the decision was made for 2008 plan to focus upon natural hazards.

Synopsis of 2009-2011 Planning Process

The subsequent cycle of plan maintenance involved a more complete update process than was possible in the previous (2008) cycle. First, the Michigan Hazard Mitigation was restored to a full and balanced consideration of all hazards—natural, technological, and human-related. Second, there were no problematic circumstances involving the status of Michigan's official hazard mitigation council (MCCERCC), which met regularly and was heavily involved in the plan update process, along with various partners and associated agencies. Third, the 2011 update process was enhanced by

meeting the additional standards of the Emergency Management Accreditation Program (EMAP), which granted Michigan's emergency management framework a conditional accreditation that is expected to be expanded into full accreditation in 2011. Finally, the plan update was assisted by the availability of FEMA-approved local hazard mitigation plans in the vast majority of Michigan's 83 counties.

Synopsis of 2011-2014 Planning Process

A strong effort was made for this newest plan update to be more evenly stretched across the full three year period that was available. After the 2011 update was completed at the end of March, 2011, new 2010 census data became available, and MSP staff worked to re-analyze the development trends section of this document. This analysis was completed in 2011 and work then turned to an update of the hazard analysis sections, which constituted nearly half of the page count in the 2011 plan. During 2011 and 2012, lead staff at EMHSD proofread, researched, and edited all of the hazard sections, and coordinated with the MCCERCC's Hazard Mitigation Committee to have each section reviewed by subject matter experts in different government departments. EMHSD staff also had weather elements reviewed by a meteorologist from Michigan State University, a meteorologist with WDIV-TV (Metro Detroit), and climate change elements were also offered at meetings of the Michigan Climate Coalition for members' review. Feedback (or approval) was received from all these agencies, and this half of the plan was initially published separately in July 2012, under the title "Michigan Hazard Analysis" (EMHSD Pub. 103). This early work on the hazard analysis half of the plan turned out to be vital for its timely completion, because several major competing demands were soon placed on EMHSD staff afterward. One was the demand that an annual Threat and Hazard Identification and Risk Assessment (THIRA) be completed (at first with limited guidance and an extremely short time schedule)—a task that at first appeared to be strongly related to the Michigan Hazard Mitigation Plan, but whose pre-determined formalisms soon felt much more distracting than helpful. The second was a major disaster declaration that occurred in the Spring of 2013 and required substantial staff time, including numerous reports, meetings, and coordination with temporary field offices. This disaster was for flooding events that occurred between April 16 and May 14, which were then followed by follow up reports and work on recovery activities and hazard mitigation grants which took many months to handle. During mid-2013, a revised draft of the MHMP Goals and Objectives section was distributed to MCCERCC and discussed by its Hazard Mitigation Committee, but those bodies had to dedicate a couple of their meetings to deal with the evaluation of post-disaster hazard mitigation grant applications. By the end of 2013, full-time work had resumed on the MHMP update, but it still took quite some doing to complete with any greater efficiency than during previous updates, just barely being finished before expiration and therefore placing burdens upon the Governor's Office to process its official approval on the originally planned schedule. During 2013, proposed legislation had appeared, which would have lengthened the three-year state update requirement into a 5-year cycle. MSP/EMHSD wholeheartedly supports that proposal, which would not only cause the state plan's time-frame to match those of local plans, but would also provide additional, much-needed time to allow staff to perform the necessary research, review, coordination, and public input opportunities. Although the 2011 edition of the plan had been posted online for review and feedback by anyone, including the full citizenry of Michigan, newly revised drafts of the 2014 plan were additionally posted, in prominent positions, on two government web sites in early 2014 and announced by social network communications (in addition to the existing MCCERCC references and open meetings which had provided a well-established mechanism for inviting review/feedback during the previous updates). The plan was also repeatedly mentioned and placed on the agendas of various meetings with partnering and coordination agencies, such as the Silver Jackets and the Michigan Climate Coalition, during 2013 and 2014, as well as in various presentation and training sessions directed at diverse audiences.

Michigan's Hazard Mitigation Plan (and smaller portions of it, such as the Michigan Hazard Analysis) are widely distributed by MSP/EMHSD, freely available on its web sites (except for the confidential content contained within Attachment A), and always include an open invitation to provide feedback to key personnel (Mike Sobocinski, at sobocinskim@michigan.gov or 517-336-2053) regarding any suggestions upon any part of its content. It is felt that the distribution of these materials to a wide array of recipients is an important part of not only achieving the plan's purpose in building awareness, expertise, and coordination, but also a part of interagency and public engagement, by which feedback is sought and obtained for the improvement of the plan. In addition to the input that is specifically requested for the review and improvement of the plan, MSP/EMHSD personnel continually consider possible ways to improve and refine the content of the MHMP as they attend meetings, workshops, conferences, provide training, or otherwise interact with diverse stakeholders throughout Michigan, including public citizens, who are able to contact

the office directly by phone, fax, and e-mail. For the 2014 update of the MHMP, it is possible a more diverse array of input and subject matter has been considered than for any previous editions of the plan—to the extent that the time to evaluate and include all these information sources could not be completely realized within the available time frame and will therefore have to feed into the next edition of the Michigan Hazard Analysis document (EMHSD Pub. 103) during 2015 (possibly 2016).

Following this general synopsis section is a section that provides more detail about precisely how (and why) each section the plan was revised. The following section provides lists of information to document the extent and nature of the outreach process undertaken by MSP/EMHSD that promoted the MHMP over the past three years and thus encouraged various input to be submitted for consideration in the 2014 MHMP update. Requests for input from numerous agencies were explicitly made at numerous times across the three-year update period (at first mainly for the hazard analysis sections), and a great amount of valuable suggestions and new information was obtained in this manner. Portions of this plan were thus enhanced by a greater awareness and emphasis upon academic, theoretical, and technical perspectives and forms of analysis. Every section of the plan was reviewed, revised, and some were partially rewritten. Great efforts were made to allow the plan to be compatible with the current scholarship, knowledge, and efforts of academic, specialist, and military agencies. The greater availability of digital online resources also proved to be enormously helpful as a source of factual information throughout the process.

Contact and communication between MSP/EMHSD staff and the involved stakeholders occurred through many means—meetings, office visits, e-mail, phone conversations, hardcopy correspondence, and conference activities. A section follows, in which descriptions of stakeholder input are provided—agencies, personnel, dates, and processes/content that were discussed for the 2012 Michigan Hazard Analysis and the 2014 Michigan Hazard Mitigation Plan Update that it led into. (The full revised text of the 2012 Michigan Hazard Analysis document was treated as an update of the 2011 MHMP's corresponding sections, and was further updated during 2013-2014 as a vital core section of the MHMP.) The level of detail used in the following list of stakeholder input has been considered appropriate for compliance with federal DMA 2000 planning requirements. In some cases, these contacts occurred at multiple times on a particular day (e.g., multiple phone calls or e-mail messages), but these are typically only listed once unless the means of contact were markedly different (e.g. a document submission in the morning, followed by an afternoon meeting, would be listed twice). The listed dates alone may reflect different amounts and quality of contact and communication, but for the sake of simplicity and accurate documentation, information is provided by date rather than the number of contacts in a given day. (For example, one phone call might be worth 30 e-mails, or the reverse may be true, depending upon the type of information being evaluated or discussed.) These details are followed by a description of the public involvement process.

Section by Section Summary of Changes Made to the 2014 Plan Update

1. Background Information Section: The text was reviewed for clarity, accuracy, tone, and relevance, resulting in various adjustments made to the wording. MCCERCC information was found to need some amendment, as well.
2. Section on Planning Preliminaries, Preparation, Participation, and Process: The text in this section was similarly reviewed for clarity, accuracy, tone, and relevance. In addition to minor adjustments, the synopses of the planning processes were revised, with the 2011 description pared down considerably, while completely new information about the 2014 update process was added. The list of Stakeholder Input has had its content entirely changed to document the new activities that were specific to the plan update process from 2011 to 2014. Finally, the Public Involvement section was revised to reflect the appropriate new information for the 2014 update.
3. Risk and Vulnerability Assessments Section: The general development process text was proofread and revised where appropriate. Old reference lists have been removed and explanation has been added regarding the difficulties in connection specific content with particular references in previous editions of the document. The list of hazard mitigation strategies has been edited down to mirror changes made in the corresponding hazard analysis subsections (see below). The glossary of mitigation terms was retained and reviewed, with minimal changes.
4. The Hazard Analysis Section: The hazard analysis section had its summary table revised to reflect new information, and the entire section had been reviewed and edited as a result of the updated July 2012 publication of the Michigan Hazard Analysis as well as later work specifically for the 2014 MHMP. Many new descriptions of historic hazard events have been added, and the flood section has been further reshaped to more closely resemble the format of other hazard-specific subsections. Numerous summary tables have been added, as compiled from the

National Climatic Data Center storm events database (online). The section on cyber-attacks has been expanded, while the lists of mitigation strategies have been edited to make them less redundant and more focused specifically upon hazard mitigation (reducing the amount of preparedness and awareness activities). Every page has been scrutinized, resulting in so many minor changes that it would not be appropriate to try to describe them all individually.

5. The Section on Local Vulnerabilities and Development Trends – Text has been revised to reflect the content of local plans that have been updated since 2011. The development pressures and trends section replaced old census data with new, resulting in substantially different lists of communities considered to face development pressures. The explanatory text for that section was reviewed and revised for clarity and accuracy.

6. Coordination Between State and Local Plans – Includes new maps and descriptions, along with substantial critical assessments of hazard mitigation planning and a new work plan to guide state-local outreach and coordination for the next three years. As with all other parts of the plan, each page was scrutinized and amendments have been made to the text in order to improve its clarity, accuracy, and timeliness.

7. Mitigation Strategy Section – The general types of mitigation tools and measures have not changed substantially in the past three years, so the expository text that provides an overview of that information was merely reviewed for clarity and accuracy, with minor adjustments made where needed. The detailed descriptions of hazard mitigation measures has been retained from the previous edition, but many objectives have had their priority level changed, and several new objectives have been added to encourage more emphasis upon significant natural hazards other than flooding. Each objective has had its current status summarized, as of early 2014, and many details have been amended to improve the accuracy, clarity, and timeliness of the content. It was decided to retain the cumulative tables of completed/retracted objectives, due to their value as a historical record, and a new table was added for 2014. The discussion of implementation and project funding was reviewed and still deemed to be appropriate, with more detailed updates incorporated into the sizeable Attachment C, which was revised for 2014 (described below).

8. Plan Monitoring and Update – The section was reviewed and revised as needed to reflect the content and status of the 2014 update.

9. Attachments – The 7 attachments parallel those which had appeared in the 2011 edition.

- Attachment A (Loss Estimates, Critical Facility Vulnerabilities, and Support Materials) was thoroughly reviewed, with new census data and facility lists used for the 2014 update. New content from MDTMB did not exactly match facility lists from the past, and a new assessment of important (but not necessarily critical) facilities caused the length of the list to grow for this edition, which was considered necessary in order to avoid inadvertently excluding places of substantial importance. A reassessment of the loss estimates was also undertaken, with a de-emphasis upon the risk ascribed to the subsidence hazard which had appeared in previous editions. The public versions of this document do not include "suppressed" information about critical state facilities. A multi-page table of precipitation analysis was moved into the hazard analysis section of the plan, where it would be more readily found and used.
- Attachment B (Disaster Declarations in Michigan) – The tables have been updated, and a new summary map has been provided.
- Attachment C (Hazard Mitigation Funding Sources and Projects) – EMHSD grant experts reviewed and updated most of this section, with the balance of its text subjected to scrutiny and editing (for clarity, accuracy, and timeliness).
- Attachment D (MCCERCC information) – All council information has been updated to describe its current agencies and membership. More detail about specific agency involvement in this plan is provided below, but when this plan refers to the MCCERCC acting as a body, or to a MCCERCC committee (e.g. hazard mitigation committee), this Attachment can be referred to for detail about who was involved in the described activities (or, in the case of the implementation of mitigation objectives, who might be involved in such activities in the future).
- Attachment E (State Flood Hazard Mitigation Plan) – This is referenced in the flood analysis section, but due to its multi-page nature, was retained as an Attachment so as to preserve the readability and formatting of the hazard analysis. As mere documentation of a previous action, no update was necessary for this 4-page section.
- Attachment F (Hazard Mitigation Strategies for Federally Declared Disasters) – A 2013 federal declaration resulted in the production of an additional report for disaster #4121, which was added to this Attachment.

- Attachment G (Review Sheets for State and Local Hazard Mitigation Plans) – Updated federal and state forms were added to keep readers and agencies informed about changes that had been made to the review forms and standards since the 2011 plan was adopted. The state review document includes some additional detail and state-specific review information, while presenting the same essential material in a more condensed format than the federal review form.

The following multi-page table provides an overview of the outreach activities, and the known agencies that were most directly involved in these activities. It focuses upon those activities that were most directly related to the maintenance, development, and update of this 2014 MHMP since 2011. In many cases, the very same MSP/EMHSD personnel were involved in both the organizing and providing of outreach and the research/editing process for the 2014 MHMP update.

2011-2014 MHMP Outreach, Input, and Coordination Activities

- April 6, 2011: Contact with Michigan Association of Planning (MAP) re: presentation on hazard mitigation planning at their annual conference (proposal was eventually not accepted by them – August 14, after their review process)
- April 13, 2011: Emergency Management Accreditation Program virtual meeting (conference call), including a discussion of MHMP requirements
- April 22, 2011:Call from MCCERCC member re: Public Health Emergencies
- May 12, 2011: "Brown Bag" lunch discussion meeting on hazard mitigation planning, with Region 6 planning commission related group of attendees
- July to September 2011: Information on local oil/gas well hazards/events was requested from all local EMCs as a part of the round of MSP District Coordinator meetings and presentations by EMHSD staff. Some information was received, but overall, it was found that the degree of risk from this hazard, statewide, appeared to be less than had been thought. (Follow-up investigations took place in 2011-2012 to further investigate the hazard in revising the MHA and MHMP.)
- May 13, 2011: MCCERCC Hazard Mitigation Committee meeting
- June 21, 2011: Contact with Paul Gross (WDIV-TV meteorologist and author of "Extreme Michigan Weather") about the extreme temperatures hazard sections of MHA and MHMP
- June 24, 2011: Oil and gas well materials obtained from MSU research library, plus a governor's report on the topic
- June 24, 2011: Part I of the 2011 MHMP sent to Precious Home Health for preparedness and planning purposes, in response to their inquiry
- July 19, 2011: A final pdf formatted version of the 2011 MHMP was posted on EMHSD web sites for general public review and feedback. (Previous postings had been of the earlier drafts of the document.) This posting was preserved until the new 2014 edition was finalized and posted in its place, and it included a request for comment along with contact information for providing feedback.
- August 1, 2011: Notice of MHMP web-posting was sent to the network of all local Emergency Management Coordinators (EMCs) and also referenced at the round of MSP District Coordinator meetings
- August 2, 2011: MHMP mailing to a full set of MSP partners and stakeholders (and follow-up correction to the email)
- August 4, 2011: Notices of online MHMP posting sent to state agency stakeholders
- August 4, 2011: Outreach to MSU faculty regarding guest lectures on Michigan hazards and hazard mitigation
- August 15, 2011: MCCERCC meeting and review of the MCCERCC coordination plan
- September 1, 2011: Contact MDEQ regarding NFIP information for updated MHA and MHMP
- September 12, 2011: Inquiry from a citizen about flood elevation in the City of Gibraltar
- September 13, 2011: Draft text on "Hazard Mitigation through Planning & Design" developed and considered
- September 28 and 29, 2011: MDCH request to assess the UCLA "Hazard Risk Assessment Instrument" – which was evaluated but not preferred to existing methods, with follow-up discussion occurring in November 2011
- October through December, 2011: SPR meetings (October 19 and 26, November 1, 15, and 22, December 1)

- October 2011: Spreadsheet programming for census trend data analysis (for MHMP development trends update)
- October 31, 2011: MCCERCC Hazard Mitigation Committee meeting
- November 3, 2011: Presentation in MSU urban planning course – UP 400 – about hazard mitigation planning
- November 7, 2011: MCCERCC meeting
- November 8, 2011: MSP/EMHSD Emergency Planning course – includes a module about hazard mitigation planning and information about state plans and guidance documents
- December 19, 2011: Examine information on Climate Change and Public Health, received from MDCH
- January 27, 2012: Contact Michigan Association of Planning about submitting an article for their publications, about the development and availability of the updated Michigan Hazard Mitigation Plan. In April follow-up, MAP contact Lauren Carlson advised about the possibility of publication in their online newsletter, to reach all their members, although a submission would occur well before actual publication (more than a year in their printed magazine, if accepted)
- January 30, 2012: Silver Jackets conference call regarding USGS stream gauge network (described in MHMP objectives) and to seek coordination between Silver Jackets and MCCERCC
- February 2, 2012: Study text on collective behavior (recommended through input from MSU sociology faculty member Dr. Perlstadt) regarding "panic" and "mass hysteria" – ideas that are popularly given more credit than they deserve (text: David L. Miller, second edition, 2000 "Introduction to Collective Behavior and Collective Action"), most heavily reflected in revisions to the Civil Disturbances section of MHA and MHMP
- February 6, 2012: Contact with Paul Gross (WDIV-TV meteorologist) to obtain information for MHA and MHMP – received information about ice storms from him on February 8 for consideration and inclusion
- February 8, 2012: MSP/EMHSD Emergency Planning course – includes a module about hazard mitigation planning and information about state plans and guidance documents
- February 14, 2012: Request and receive MDEQ information on detailed flood analysis techniques – contact with Bruce Menerey, Les Thomas, Linda Burke (February 15)
- March 1, 2012: Presentation at MSU on hazard mitigation and emergency management, for UP490/890 class of graduate students and practicing planning professionals
- March 15, 2012: Contact with Michigan Climate Coalition (MCC)
- March 26-27, 2012: Coordination with MCC begins, with MSP as a new member, explanatory text being sent for inclusion on their web site March 29
- March 29, 2012: Contact with Silver Jackets (SJ) to follow up from January 30
- April 4, 2012: Received THIRA (Threat and Hazard Identification and Risk Assessment) guidance document and mandate from FEMA
- April 10-11, 2012: State Hazard Mitigation Officer (SHMO) conference held in Lansing, and includes discussion of hazard mitigation planning with FEMA
- April 13, 2012: Contact with MDEQ regarding nuclear and hazardous materials text in MHA and MHMP. Ken Yale provides review and feedback (also on April 16)
- May 7-10, 2012: THIRA conference call and meeting (May 8 THIRA training preparation, May 10 THIRA meeting)
- May 12, 2012: THIRA meeting (NOTE: THIRA was one relevant means of coordination about MHMP topics by involved agencies, even though the formal THIRA/SPR process was considered too rigid and artificial for use in the MHMP)
- May 15, 2012: Requested and received cyber-attack information from Denise Barnes of the Michigan Intelligence Operations Center (MIOC) for consideration in MHA and MHMP
- May 16, 2012: Consideration of federal CPG 201 THIRA supplement document
- May 22, 2012: Develop state profile map with GIS staff for use in MHA, draft THIRA, MHMP
- May 25, 2012: Nuclear attack section revisions received from Sean Brady of MSP/GCSD
- May 29, 2012: Revision to grant information section in MHMP – feedback from Sean Brady and Mary Mankowski of MSP/GCSD regarding the terrorism programs and initiatives subsection in MHA and MHMP
- May 30, 2012: Terrorism section and revisions received from Sean Brady of MSP/GCSD for MHA and MHMP

- June 4, 2012: MHA information shared with THIRA draft and incorporates Urban Areas Security Initiative (UASI) regional homeland security plan info (confidential)
- June 6, 2012: National level exercise on cyberterrorism provides some useful information for the cyber-attack section of MHA and MHMP
- June 7-8, 2012: THIRA and SPR training sessions (FEMA Chicago)
- June 11, 2012: MCCERCC Hazard Mitigation Committee meeting
- June 13, 2012: Additional MHA information shared with THIRA draft document
- June 13, 2012: Contact with Michigan National Guard (MING) Allison Etheridge regarding the MING all-hazard plan and MING review of the MHA (which then became part of the 2014 MHMP with further updating). The mutual reviews were accomplished over subsequent months.
- June 18, 2012: MCCERCC meeting includes THIRA presentation
- June 20, 2012: County Business Pattern info from federal Department of Commerce – used for updated state profile information in MHA and MHMP
- June 21, 2012: THIRA meetings begin (additional meetings occurred on June 28, July 12, July 19, July 26, August 2, August 9, August 30, September 13, September 20, September 27, October 4, October 18, October 25, November 8, November 27, and November 29; and conference calls on June 27, July 31, September 26, October 1 and 2, and October 30; THIRA included consideration of worst plausible scenarios for events such as pandemics, cyber-attacks, chemical attacks, winter storms, tornadoes, and improvised explosive device incidents, and thus its scenarios were relevant for numerous sections of the MHA and MHMP)
- June 28, 2012: Discussion with MDEQ Steve Wilson regarding updated oil/gas well information for MHA and MHMP
- July 2, 2012: Well count information received from MDEQ for MHA and MHMP
- July 17, 2012: Meeting with Mike Kenel of Michigan Public Service Commission on THIRA, infrastructure failures, cyber-attacks (also relevant for MHA and MHMP)
- July 18, 2012: Presentations to "Rural and Ready" conference and CERT group, at separate locations in Sault Ste. Marie, on hazard mitigation planning, publicizing the new MHA and requesting review/feedback on MHA and MHMP
- August 15, 2012: Input on hazard mitigation topics provide to MDOT long-range state transportation plan
- August 20, 2012: MCCERCC meeting and presentation
- September 12, 2012: THIRA scenarios work – coordinated with multiple agencies – continues on September 18, 19, 21, 25, 27, October 3, 17, 19, 22, 24, 25, 30, etc.
- September 14, 2012: MDEQ scrap tire information provided by Ronda Euler for MHMP update
- October 3, 2012: Coordination with MDEQ Byron Lane regarding dam safety information for MHMP update
- October 19, 2012: Meeting with MDEQ Byron Lane and visit MDEQ for information on dam emergency action plans
- October 23, 2012: Presentation at MSU in SOC 375 urban sociology class about hazard mitigation concepts and activities in Michigan, including MHA and MHMP
- November 5, 2012: MCCERCC meeting
- November 7, 2012: Presentation on hazard mitigation concepts to MSU class SOC 801 (global transformations)
- November 14, 2012: MSP/EMHSD Emergency Planning course – includes a module about hazard mitigation planning and information about state plans and guidance documents
- January 17, 2013: Michigan Climate Coalition (MCC) meeting in Lansing – seek feedback on climate change text in MHA and MHMP
- January – begin developing updated presentations on hazard mitigation planning for MI-CEMKR (Michigan Core Emergency Management Knowledge Requirements) course; updating of grants table for MHMP
- January 23 and 29, 2013: Develop and revise a local coordination plan for MHMP to prioritize its direct planning assistance to local EM programs in Michigan
- January 28, 2013: Contacts with MCC members regarding Great Lakes water levels, shoreline hazards section of MHA and MHMP sent for review by MDEQ Roger Eberhardt

- January 31, 2013: Web meeting and demonstration to investigate "Odysseus" hazard analysis capabilities (IS consultants)
- February 1, 2013: Request review of MHA/MHMP section by Niles Annelin of MDOT
- February 25, 2013: Review of MHA/MHMP terrorism topics by Sean Brady of MSP/GCSD
- March 5, 2013: MHA/MHMP weather hazards sections sent to MSU meteorologists (in the Department of Geography), then reviewed by Jeff Andresen
- March 7, 2013: Submit proposal for MAP conference session (eventually not accepted by their selection panel)
- March 9, 2013: Received requested information on flood mitigation and RiskMap from Les Thomas of MDEQ
- March 21, 2013: MCC meeting in Lansing
- April 2, 2013: Presentation at MSU in UP 488 (sustainability planning)
- April 3, 2013: Silver Jackets conference call and discussion/arrangements for StreamStats GIS initiative for USGS and coordinating agencies such as MDEQ, MSP, etc.
- April 12, 2013: Contact Jeff Andresen (MSU Geography – meteorologist/climatologist) regarding MHA/MHMP sections
- April 15, 2013: MCCERCC meeting and presentation
- April 16 to May 14, 2013: Disaster 4121: flooding in 16 Michigan counties (produces disaster strategy now included in Attachment F of the MHMP)
- April 19 to 27, 2013: Preparation of new trial event, "Geologic Mapping," on flood risks for the Michigan Science Olympiad held at MSU on March 27, but potentially adaptable for all states in this annual event (educational awareness and outreach on hazard risks and mitigation)
- May 16, 2013: MCC meeting, including discussion of future presentations to the MCCERCC on the topic of climate change
- May 22, 2013: Conference call regarding GLISA coordination and grant availability
- June 17, 2013: MCCERCC meeting and presentation
- June 18, 2013: Inquiry with MDEQ Susan Parker regarding the Toxic Release Inventory (and its potential use in analyzing hazardous materials incidents in MHA and MHMP)
- June 18, 2013: Contact with Ontario Emergency Management (Patricia Martel) and obtain the Ontario HIRA for review. Ontario review of MHA and MHMP invited.
- June 19, 2013: Silver Jackets meeting at MDEQ office (including a phone-in option)
- June 20, 2013: Check with computer expert at MSU (P. Laurens) regarding a good non-technical overview of cyber-attack risks. Received recommendation of Bruce Schneier materials.
- June 24, 2013: FEMA conference call regarding Disaster Mitigation Strategy
- July 1, 2013: Contact EM offices for Ohio, Indiana, and Wisconsin, to invite their review of MHA and MHMP, and obtain hazard mitigation plans for these (adjacent) states for review and consideration
- July 3, 2013: Contact MDEQ Jennifer Wolf regarding County Forest Plan information in Michigan
- July 9, 2013: Grand Rapids meeting with FEMA on disaster 4121 Hazard Mitigation Strategy
- July 9, 2013: Inquire with Gary Becker (MSP Commercial Vehicle Enforcement Division) regarding the transportation accident and hazardous materials sections of the MHA and MHMP
- July 10, 2013: Inquiry from Region 14 planning office (Muskegon; Stephan Carlson) regarding hydraulic fracturing as a potential source of risk to include in hazard mitigation plans (concerns expressed at the local level by citizens). Initial answer is that there is no known concern, but subsequent investigations later become somewhat involved (although ultimately reaching a conclusion that did not change much: few strong reasons for concern in Michigan, unlike some other states, due to differences in bedrock geology, state regulations, and the smaller extent of the extraction industry)
- July 15, 2013: Contact with Tony Adduci (FEMA) regarding the production/assessment of an updated list of critical facilities for the MHMP (Attachment A)
- July 18, 2013: MCC meeting, requested review of Energy Emergency section of MHA/MHMP from David Gard (Michigan Environmental Council)
- July 22, 2013: Contact with MDTMB Kathy Knapp regarding new state facilities data for MHMP

- July 26, 2013: Read Natural Hazard Mitigation Association (NHMA) material (from online)
- July 29, 2013: Obtain US Forest Service wildfire report
- August 5, 2013: MCCERCC Hazard Mitigation Committee meeting
- August 8, 2013: MDOT feedback on hazard mitigation strategies obtained from Eileen Phifer
- August 9, 2013: Contact with Jason Nairn and Jeanette Doll of MDTMB regarding the use of new state facilities lists and their partial processing by Tony Adduci of FEMA (follow-up contact on August 12, 15, and September 20; obtained lists forwarded to Tony on September 23)
- August 9, 2013: Contact with Mary Weidel of Silver Jackets and US Army Corps of Engineers to exchange information for planning purposes
- August 13, 2013: Revised MHMP objectives distributed to MCCERCC Hazard Mitigation Committee members
- August 19, 2013: MCCERCC meeting (pre-council meeting with Hazard Mitigation Committee chair, Phil Schertzing)
- August 23, 2013: Received new THIRA guidance from FEMA
- August 29, 2013: Formal request to MDTMB for state facilities list (Jeanette Doll)
- September 5, 2013: After relaying concerns and interest similar to that of another inquiry (see July 10), the Region 7 planning office sends a series of articles, web links, and references for consideration in the MHMP, about the use of hydraulic fracturing in natural resource extraction industries. (Additional information was sent by the Region 7 office on October 3, 12, 16, 18, 22, 25, 31, November 7, December 2, 7, February 18, 2014, and March 12, 2014.)
- September 19, 2013: MI-CEMKR training includes a 3.5 hour module on hazard mitigation planning (course held by EMHSD at a Spring Arbor College location in Lansing)
- September 20, 2013: FEMA workshop on THIRA/SPR (Vince Parisi)
- September 26, 2013: FEMA webinar on hazard mitigation planning (supported by and announced by MSP/EMHSD for local EMCs)
- September 30, 2013: MCCERCC Hazard Mitigation Committee meeting
- September 30 to October 1, 2013: Receive lists of state facilities from MDTMB and (on October 21) relay them to Tony Adduci of FEMA for some partial initial processing (along with instructions and comparison tables from the 2011 plan)
- October 14, 2013: Review FEMA "losses avoided" study for Michigan
- October 24, 2013: THIRA/SPR conference call
- November 4, 2013: MCCERCC meeting and presentation
- November 21, 2013: MCC meeting and the receipt of Huron River Watershed Council information
- December 4, 2013: Presentation at MSU on Michigan hazards, for SOC 375 urban sociology class
- December 5, 2013: Region 7 planning office (Saginaw) sends information about a propane tanker incident in Cheboygan County, for MHA and MHMP consideration
- December 12, 2013: MI-CEMKR course presentation at MSP Training Academy, including a module on hazard mitigation planning
- December 12, 2013: Contact with MDOT regarding a climate vulnerability assessment process, inviting MSP/EMHSD to participate in the assessment (see January 29, 2014)
- December 18, 2013: THIRA/SPR meeting
- January 14, 2014: Dominic Smith of MDCH sends information on climate change and public health
- January 24, 2014: Received partially processed state facilities information from Tony Adduci (FEMA)
- January 29, 2014: MDOT climate change meeting at Lansing Capital City International Airport
- February 14, 2014: Weather section of MHMP sent to Paul Gross (WDIV-TV meteorologist) for review
- February 15, 2014: Hal Fitch of MDEQ provides feedback on hydraulic fracturing inquiry
- February 18, 2014: New inquiries are made with MDEQ to verify accuracy of MHMP draft text on hydraulic fracturing. (Note: additional email contact made with Jennifer Wolf on February 28 and March 3-4, 2014.)
- February 19, 2014: Requested feedback from USGS is obtained regarding the current status of their StreamStats objective

- February 24, 2014: Drafts of the MHMP are made available on MSP web sites for review/feedback, while they're being finalized—these postings are publicized through social media and web links, MCCERCC open meetings, EMHSD partner agencies and networks, and invited feedback from subject matter experts.
- February 24, 2014: MCCERCC meeting, preceded by Hazard Mitigation Committee meeting
- February 25, 2014: Silver Jackets meeting, information provided about draft MHMP web-postings, and request for feedback on the plan from partnering agencies and their own networked affiliates
- February 27-28, 2014: Feedback on weather sections and climate change references received from Paul Gross (see February 14), with MHMP amendments resulting from this feedback
- March 3, 2014: Contact with MDEQ (Jennifer Wolf, Don Johnson, Mel Kiogima, and Steven Burton), resulting in MHMP review and feedback
- March 6, 2014: Contacted by J. Harkness of CIP (MIOC) regarding MHMP analysis and facilities list
- March 10, 2014: MCCERCC meeting and plan approval (of main sections of the plan, with minor factual and procedural portions which were less relevant for council overview amended afterward for FEMA review and governor's approval, with MCCERCC recommendation of greatest relevance to demonstrate coordinated agency input and facilitation of governor's official approval)
- Late March, 2014: FEMA review of MHMP finds it to meet requirements
- Late March, 2014: MHMP adopted by MSP/EMHSD
- Late March, 2014: MHMP adopted official by Governor Snyder.

NOTE: The preceding list does not attempt to provide a complete list of those who attended presentations, conferences, workshops, meetings, etc. through which MSP/EMHSD distributed materials and sought feedback about local/regional hazard vulnerabilities, mitigation project status, and other topics relevant to this plan. To attempt such a list would require access to all of the registration and sign-in information from those events, not all of which were actually hosted by MSP/EMHSD. Therefore, this note has been added to provide examples of some of the non-profit, private, or non-governmental organizations have been involved in these activities and thus have been part of MSP/EMHSD's outreach efforts on behalf of local and state hazard mitigation planning. It should also be noted that today, an agency's web sites often provide a form of official outreach and information from that agency, without any direct agency contact (i.e. interpersonal) needing to take place. A few of these circumstances have been included in the preceding list, especially when they involve agencies not otherwise credited within this updated 2014 MHMP. For example, in the past, an agency might have been contacted in order to formally request information or guidance, but now the same materials might be freely available to obtain through online sources without official contact to request them.

(The same MSP/EMHSD personnel that have trained, overseen, reviewed, coordinated, facilitated, promoted, and otherwise been involved in the production and review of local mitigation plans have also been involved in the core research/editing team involved in the production of this 2014 MHMP update, thus providing a clear and convenient link between the various levels and types of planning, and the partnering agencies of all types that have been involved in these processes.)

Some overarching events occurred during the 2011-2014 update period, including the release of new 2010 census data that included locally detailed breakdowns of key indicators, the collection and multi-agency review between August 2011 and July 2012 of an updated edition of the Michigan Hazard Analysis (which had originally appeared as a part of the 2011 MHMP), new FEMA planning guidance and resulting plan review forms, a May 2012 emergency in the "Duck Lake" wildfire that seriously affected Luce County and part of Schoolcraft County, the start and expansion of federally mandated THIRA/SPR activities, and the federally declared 4121 flooding disaster in 16 counties during mid-2013, after which the procedure of updating the MHA and the rest of the MHMP was resumed.

The various conferences, training courses, and coordination meetings in which MSP/EMHSD has participated have included attendees from an enormous variety of professions and organizational types. Other sections of this plan have referred to the coordination with Native American organizations, the urban/regional planning profession, emergency management and response organizations, and governmental entities at all levels. In addition, however, there exist many connections with non-profit, corporate, and non-governmental agencies—often through attendance at meetings,

conferences, training courses, emergency management exercises, and other means of outreach and coordination. These have included representatives from hospitals and health agencies, the insurance industry, radio operators (R.A.C.E.S./ARES), businesses (often risk-management personnel or other key persons concerned with safety and hazard mitigation), schools and private colleges, the American Red Cross, and even large corporations such as Michigan's major automotive manufacturers. Outreach to subject matter experts in academia has also been maintained, and subject matter experts consulted where appropriate for their knowledge, regardless of current employment. For example, a meteorologist for a broadcast television station provided important information and review of weather hazard sections, various survey organizations both private and academic were contacted in developing part of the consequence analysis section. Hazard mitigation plans for the adjacent states of Ohio, Indiana, Wisconsin, and the Canadian Province of Ontario were obtained through the internet and their content considered. At the same time, these agencies were notified by email of the update process for the Michigan plan, and invited to review and comment upon it. Text overview suggests the diversity of the many attendees at conferences and training courses who have been provided with information about hazard mitigation planning, and from whom various information was obtained and considered for inclusion in this updated 2014 MHMP.

Many of these conferences, meetings, training courses, and outreach activities also included members of the general public, who were also provided with contact information usable to reach MSP/EMHSD planning personnel and ask questions or provide comment/feedback about planning processes and documents, including the MHMP.

The most significant recommendation issue received for the 2014 plan, without specifically being requested, involved two separate regional planning offices, each of which had inquired about the risks of hydraulic fracturing. One sent large amounts of material regarding the types and amounts of damage that had been associated with hydraulic fracturing in other states. These materials were given extensive consideration, and some were referred to subject matter experts from the MDEQ for assessment.

Public Involvement and Outreach Activities for the 2014 MHMP update

This plan was developed in coordination with the MCCERCC—a visible state agency with its own web site and a regular open meeting schedule that allows the attendance of citizens. Various citizens have observed the MCCERCC meetings over the years, and although some communication took place that allowed a discussion of hazard mitigation, emergency management, and planning activities, there were no specific comments provided that needed to be reflected specifically in this plan update. Rather, the interaction involved the kind of exchange that has been common in the numerous outreach activities provided by MSP—the provision of information, answering of questions, discussion of planning and mitigation options, provision of guidance and materials, web links, and so on. Reactions to review drafts of the MHMP have been positive, and have given the impression that the document is very impressive for citizens and professionals alike. (It seems to be good enough that most persons, expert or lay, rarely have suggestions about how to improve it. One exception is that some MDNR staff do feel that the Invasive Species chapter should be completely overhauled. This task is therefore planned for the next update of the Michigan Hazard Analysis, during 2015 or 2016.) Interest in MSP training courses and conferences has been strong, and there is continued interest in having EMHSD staff provide outreach to communities (at local meetings) and students (in college courses). Since the same staff members who are involved in these outreach activities are also the ones who are involved in the update of the MHMP (as well as the review of local plans, which have their own associated public involvement requirements), the reactions and ideas of the public could therefore be gauged even when such contacts did not include specific and formal "feedback," and instances of doubt, uncertainties, concerns, confusion, or questions could be discussed personally through these meetings. In other cases, various officials and representatives attended and anonymously relayed concerns or ideas that had been expressed by citizens who had communicated with the jurisdictions or agencies that they oversee or represent. Through such discussions and feedback, various amendments have been made to the text of the MHMP to help update the document to better reflect these concerns, clarify content, and make the sometimes technical aspects of the subject more accessible. As already described, relevant subject matter experts were sought out for involvement and input even if they were not officially representing a specific partnering agency. A pattern was noticed that feedback at the level of state planning was more heavily weighted toward the middle and professional classes, while feedback at the level of local planning was more likely to include a broader array of backgrounds and concerns in its citizens. This makes sense in terms of the greater awareness and direct impact that

the local governments have upon the property and lives of the average citizen, and thus reinforces the need for the state level plan to continue to coordinate with the processes involved in local plan development, and to consider the public input obtained at the local level in terms of its relevance for state-level planning. Obtaining representative citizen feedback is often a challenge for all planning processes—especially those that operate on a fairly specific timeframe and deal with a sometimes complex topic that can include sensitive information (e.g. pipeline locations) that needs to be handled delicately or (as in the case of the state critical facilities list) kept somewhat confidential. Therefore, in addition to the specific outreach and public involvement opportunities described in this plan, MSP/EMHSD personnel have also tried to incorporate additional public concerns as reflected in discussion, newspaper letters/editorials, broadcast media discussions, internet postings, political presentations, and so on. EMHSD planning staff has, since 2012, included in its activities the perusal of compiled media reports that pertain to the Michigan State Police and its activities. In early 2014, an additional compilation activity was added to consideration, involving all identified media reports involving emergency management activities and conditions in Michigan. These, plus weekly updates from the MDNR, are part of the ongoing information sources that are tapped to learn about new events and programs.

The MSP/EMHSD was required by MCCERCC provisions (Michigan Executive Order 2007-18) to operate using certain protocols with regard to the development and revision of the MHMP. As a result, MSP/EMHSD staff activities related to the MHMP were necessarily funneled through the multi-agency MCCERCC framework. Since the creation of the MCCERCC, the MHMP has been included as an agenda item at numerous meetings. (The use of formal agenda items in this way helps to direct specific attention to the MHMP as part of the announcement and open meeting provisions under which the MCCERCC operates within a public government framework). The following is a list of dates (and, when appropriate, MCCERCC minute excerpts) during the current 2011-2014 MHMP update period, for full MCCERCC meetings that were open to public attendance and comment:

- August 15, 2011 – Dr. Wagoner presented the report for the Hazard Mitigation Committee and moved that the Council adopt and approve the 2011 Michigan Hazard Mitigation Plan. Mike Sobocinski, Hazard Mitigation Specialist, presented an update on the plan. Discussion was held on the motion. The motion was adopted.
- November 7, 2011
- June 18, 2012 – Mike Sobocinski introduced the Threat and Hazard identification and Risk Assessment (THIRA), a new Federal Emergency Management Agency (FEMA) process required for all states that use FEMA funds. A THIRA draft document is available for public review and comment on the Michigan State Police Emergency Management and Homeland Security Division web page under Emergency Management and Homeland Security Publications.
- August 20, 2012 – Dr. Wagoner and Mike Sobocinski presented the report for the Hazard Mitigation Committee, which included the review of the Michigan Hazard Analysis and the five steps involved with THIRA, a new Federal Emergency Management Agency (FEMA) mandated process for all states that use FEMA funds.
- November 5, 2012 – Dr. William D. Wagoner and Mike Sobocinski presented the report for the Hazard Mitigation Committee, which included review and updates regarding the Michigan Hazard Analysis and Threat and Hazard Identification and Risk Assessment (THIRA). The review process regarding the THIRA draft document is now complete.
- April 15, 2013 – Mr. Michael Sobocinski presented for the Hazard Mitigation Committee on behalf of Dr. William Wagoner, Chair. Mr. Sobocinski distributed handouts and referenced a one-page update with an attachment from the Federal Register of March 1, 2013. He explained that the handout provides information on the progress toward the required update of the Michigan Hazard Mitigation Plan which was approved in March of 2011. The attachment was a proposal to shift the current three year update cycle into a five year update cycle. Until the proposal becomes official, they must proceed as is because of the importance of the plan. Mr. Sobocinski suggested that the Hazard Mitigation Committee hold a meeting prior to the June MCCERCC meeting in order to begin a more detailed input process.
- June 17, 2013 – Mr. Michael Sobocinski reported on the status of the Hazard Mitigation Plan update, distributed information, and gave an explanation of the process.

- August 19, 2013 – Mr. Michael Sobocinski reported on the Michigan Hazard Mitigation Plan (MHMP) update. He distributed a handout regarding the status of the MHMP update process, as well as a State Hazard Mitigation Strategy proposed list of updated objectives for the 2014 plan edition.
- November 4, 2013 – Dr. Schertzing introduced Mr. Michael Sobocinski who distributed a handout and presented on the status of the Michigan Hazard Mitigation Plan (MHMP) update process.
- February 24, 2014 – Dr. Phillip Schertzing, Chair of the Hazard Mitigation Committee, reported that their Committee had just met. He noted that the current Michigan Hazard Mitigation Plan (MHMP) will expire in March and there is a limited amount of time for the updated plan to be finalized, reviewed, approved, and routed through chain of command prior to submission to FEMA. He proposed that the MCCERCC reconvene in March in order to discuss/vote on the plan. Mr. Michael Sobocinski distributed a handout and presented on the status of the Michigan Hazard Mitigation Plan (MHMP) update process. Chair Kelenske presented a motion that the MCCERCC reconvene on March 10, 11, or 12, 2014, to review the component of the MHMP document, as well as other elements that will be posted on the EMHSD Web site. He noted that information regarding this process will accompany e-mail notification of the March meeting. The motion was supported by Ms. Eileen Phifer. Motion passed.
- March 10, 2014 – Dr. Phil Schertzing summarized that the purpose of the meeting is to seek endorsement from the Council to submit the Michigan Hazard Mitigation Plan (MHMP) to the Governor's Executive Office, through the Michigan State Police chain of command, for approval and signature. He noted that Council members had expressed the need to review a final draft of the Plan to ensure there were no conflicts with their respective departments' policies or programs. As a result, Mr. Michael Sobocinski had received comments and proposed changes pertaining to the goals and objectives component of the Plan. Dr. Schertzing presented a motion for Council members to approve the revised, updated MHMP, which includes a goals and objectives component entitled "Mitigation Opportunities, Recommendations, and Implementation," in order to submit the document to the Federal Emergency Management Agency (FEMA) prior to the current plan's March 25, 2014, expiration date. Mr. Doran Duckworth noted that the MHMP is a state of Michigan government document on which the MCCERCC acts as an advisory body. He indicated there are a number of stringent Federal requirements in the 900 page document, but the key sections are the goals and objectives which are actionable items. There was brief discussion among members regarding the importance of the MHMP as it relates to local emergency management coordinators. Chair Kelenske made a motion to support Dr. Schertzing's MHMP proposal. Motion was supported by Mr. Brad Deacon. Motion passed.

All of these meetings were open to the public and were advertised in accordance with the Council bylaws and the Michigan Open Meetings Act, thus providing various opportunities for citizens and stakeholders to personally attend meetings and offer comment on any topic related to the MHMP, in addition to the ongoing ordinary means available to contact MSP/EMHSD staff by phone, fax, or e-mail regarding the MHMP and related topics. In addition, interested individuals and organizations could submit written comments at any time to the Council and/or the MSP/EMHSD planning staff, using regular U.S. mail or through the MCCERCC web page on the MSP/EMHSD web site (or as also presented on the general michigan.gov web site). These web addresses are
http://www.michigan.gov/msp/0,4643,7-123-60152_62790-14743--,00.html and
http://www.michigan.gov/msp/0,4643,7-123-60152_62790-198426--,00.html ,
and they display clearly identified means for citizens to contact the appropriate staff to provide feedback, as well as to read meeting minutes, agendas, and MCCERCC meeting schedules. The meeting minutes document that public comment opportunities were provided (and occasionally utilized) at Council meetings themselves. (Other means of feedback to MSP/EMHSD staff and MCCERCC committee members, such as by phone, wouldn't necessarily include and relay to staff the means by which the contact information had been obtained, for documentation and analysis of the effectiveness of the feedback opportunities.)

Each edition of the plan itself (and the companion hazard analysis, published in July 2012 as a stand-alone document) has included an invitation for comment, and provided readers with contact information. Any readers of this plan can contact Mike Sobocinski of the MSP/EMHSD, with questions, comments, or recommendations concerning the Michigan Hazard Mitigation Plan. Consideration will be given for the inclusion or revision of information in the 2014 edition of the MHMP until March 2014, after which the information would be considered for the following update

process which is scheduled for completion by March 2014. Mike's primary means of being contacted is by telephone at (517) 336-2053, and by e-mail at sobocinskim@michigan.gov. The 2011 edition of the MHMP had been posted continuously since its publication until its replacement with the new 2014 edition—a total of three years on the MSP/EMHSD web sites with this invitation for feedback and suitable contact information for providing comment.

An MSP/EMHSD web site includes a description of the current MHMP and offers another location where public inquiries and comment about the plan can be guided back to EMHSD planning staff. This web address is http://www.michigan.gov/msp/0,4643,7-123-60152_62790---,00.html.

The MHMP is also distributed through professional networks (such as those of emergency managers and planners), and to those other citizens who have specifically requested a copy. Copies are widely distributed to those personnel and their associated agencies, along with the numerous MSP/EMHSD planning partners who have been involved in the plan's production and update. Editions of the MHMP that include information about Michigan's critical facilities can be made available to authorized personnel only, with the agreement that such information must remain confidential. Document distribution has also included registered participants in MSP/EMHSD training courses.

In accordance with Michigan law, the MSP/EMHSD was required to provide hard copies and CDs of its planning documents to the Library of Michigan for public review at that facility and for distribution to the state's 64 depository libraries. This allows for public review of the Michigan Hazard Mitigation Plan at any of those depository libraries.

For the 2014 update, drafted sections were made available via the web sites during late 2013 and early 2014. For the first time, MSP/EMHSD expanded its notification procedure beyond those already described to make use of newly popular social media resources. MSP/EMHSD used its Twitter account to direct traffic to the 2014 draft Michigan Hazard Mitigation Plan on the appropriate web sites. The division's Twitter account has more than 5,500 followers, consisting of emergency management personnel, media producers and reporters, politicians, and members of the general public.

The opportunity for public input is also required for local planning activities, with their own associated update cycles (every 5 years) that are ongoing in Michigan's counties and major municipalities, and whose results have been analyzed for inclusion in this 2014 plan revision. As already noted, dozens of plan development meetings, training sessions, and coordinating meetings were held across the state since the last MHMP update was federally-approved in 2011. Pertinent comments and ideas from those local planning meetings were noted for consideration during the 2014 update process.

2014 Plan Adoption and Promulgation

The 2014 MHMP process led to official adoption and promulgation by the MCCERCC, the State Director and Deputy State Director of Emergency Management and Homeland Security (the two highest ranking emergency management / homeland security officials in Michigan), and Governor Rick Snyder. The final dates for these parts of the process can be found on the official promulgation letters that appear at the beginning of the document (immediately following the Table of Contents, before page 1). Sections of the plan were submitted electronically for FEMA review starting in February 2014, and that process was completed in March 2014, with a final version of the MHMP then submitted in its entirety to the FEMA Region V office in Chicago, after approval was received for the review draft and after state promulgation activities had been completed. With that submission, approval was requested as a Standard State Hazard Mitigation Plan under the standards of the Disaster Mitigation Act of 2000, and based upon FEMA's favorable review of the advance review draft of the document. The plan will also be provided to EMAP for use in that organization's upcoming accreditation decision regarding Michigan's status as an EMAP-accredited state, to maintain continued accreditation status.

Plan Distribution

The final plan will be published online, and also available upon request (or for distribution under certain conditions) in CD-ROM and hardcopy formats, and will be distributed to members of the emergency management and homeland security communities, MCCERCC members and their agencies, as well as professional planning agencies and

registered MSP/EMHSD course attendees. Only some of the content in Attachment A is withheld from online posting and other general distribution. Distribution procedures assure that all of MSP/EMHSD's most important partnering agencies, along with interested members of the general public will receive copies of the plan and be encouraged to provide comments and feedback. Copies will also be provided to the Library of Michigan for distribution to depository libraries (in accordance with state law), and to members of the Michigan Legislature, and to stakeholders involved in the 2014 plan review/update process. This plan document itself encourages interested parties to submit comments and suggested revisions to the MCCERCC and/or MSP/EMHSD planning staff for consideration in future updates. The web sites and other contexts of MHMP distribution are designed to invite such feedback.

Integration with Other Ongoing State Planning Efforts

The state mitigation planning effort has been integrated with a number of other, ongoing state-level planning efforts. Various objectives listed under the four goals outlined in the "Mitigation Opportunities, Recommendations, and Implementation" section deal directly with maintaining and/or increasing the coordination of state mitigation efforts with other ongoing state programs and planning efforts. Recent enhancement of the Silver Jackets coordination mechanism, participation of MSP/EMHSD in the Michigan Climate Coalition, continued use of urban planning networks, and similar activities, all provide new and potentially expanding means to coordinate with other planning efforts.

Integrating Hazard Mitigation into the Comprehensive Planning Process

For example, one of the most basic priorities outlined in this plan is the statewide integration of hazard mitigation principles and practices into the comprehensive planning process at the local government level. If such integration were to be achieved on a statewide basis, the state of Michigan could reduce the number of new developments and structures or redeveloped areas that are at risk to a variety of hazards. This effort is being approached from several angles in this plan, including:

- Educating professional and lay planners about mitigation principles and practices to enhance plan integration efforts.
- Encouraging the effective use of land use and land development (regulatory) tools to mitigate hazards.
- Developing and disseminating planning guidance that provides instruction on the integration of mitigation into comprehensive planning.
- Continued participation in national, regional, state, and local efforts to integrate hazard mitigation into land use and land development mechanisms (e.g., through the American Planning Association, Michigan Association of Planning, Michigan Land Use Leadership Council; etc.).
- Coordinating state and local hazard mitigation planning efforts.

(Refer to "Goal 2: Reduce Property Damage" in the "Mitigation Opportunities, Recommendations, and Implementation" section for more detailed background information on and specific objectives related to these integration efforts.)

Integrating Hazard Mitigation into the Michigan Emergency Management Plan

The state hazard mitigation planning effort has also been integrated with the "Michigan Emergency Management Plan (MEMP)," the state's emergency operations plan developed pursuant to 1976 PA 390, as amended (the Michigan Emergency Management Act). The MEMP, which addresses all phases of emergency management, assigns specific mitigation tasks to state agencies in an effort to reduce the hazard vulnerability of state owned/operated facilities, or local facilities that state agencies may assist in the construction of using state and/or federal grant funding. For example, the Michigan Department of Environmental Quality is tasked in the MEMP to "maintain programs to protect the operational and structural integrity of public water distribution and wastewater treatment systems." Similarly, the Michigan Department of Natural Resources is tasked to "coordinate wildfire mitigation and prevention activities" and "promote urban forestry measures to minimize ice- and storm-related damage," and so forth. A number of state agencies have been assigned similar mitigation tasks in the MEMP, which helps to further institutionalize the concept of hazard mitigation in the state's emergency management program. Mitigation activities are being fully incorporated (or strengthened where necessary) in the newest edition of the MEMP. On the flip side, aspects of the MEMP have

shaped portions of this hazard mitigation plan—most notably sections such as Catastrophic Incidents (National Emergencies) and Terrorism. EMAP accreditation standards require this integration of state-level hazard mitigation and emergency response plans.

State Flood Hazard Mitigation Executive Directive

The state hazard mitigation planning effort also helps ensure that mitigation principles and practices are taken into account when state agencies site and construct public facilities and infrastructure such as state buildings and roads and bridges. In fact, for flooding, this has been mandated through the issuance of the Governor's Executive Directive 2001-5, "State Flood Hazard Mitigation" (which can be found in Attachment E). This Executive Directive, issued on September 11, 2001, requires all Michigan state agencies to adhere to the provisions found in the State's original flood hazard mitigation plan—Executive Order 1977-4, dated May 13, 1977—which requires state agencies to evaluate flood hazards when planning and constructing state facilities and avoid flood prone areas to the extent practicable. Executive Order 1977-4 (included as Attachment E) also requires state agencies to flood proof existing facilities whenever practical and economically feasible, attach deed restrictions to flood-prone state lands being sold or distributed to the public, and take flood hazards into consideration when evaluating land use plans submitted for programmatic purposes.

From a practical standpoint, the effectiveness of these two gubernatorial edicts at preventing state agency development in flood hazard areas will be a function of a number of factors, including the willingness of the Governor and the state agencies to enforce the basic hazard mitigation principles, the costs associated with developing in an alternate area, the level of knowledge, understanding and acceptance of mitigation by all involved parties, and the political, social and economic environment in place at the time the decision has to be made. Simply put, a Gubernatorial Executive Order or Directive is only as effective as those involved at the time want it to be. Although essentially carrying the weight of law, such edicts can be rescinded by future Governors or simply ignored by the involved parties. If the Governor does not enforce the measures through the Cabinet-level agency directors and their support staffs, the measures can easily become ineffective. On the other hand, if the Governor in office at the time of the development decision actually enforces the provisions, these two documents can be very effective at limiting or eliminating state-sponsored development in flood hazard areas.

Integration with FEMA Mitigation Programs and Initiatives

The process used to develop this plan is necessarily intertwined with numerous FEMA mitigation programs and initiatives in that 1) the mitigation planning requirement originated at the federal level and the planning therefore must follow the established federal guidelines, 2) some of FEMA's programs can possibly be used to fund the implementation of specific objectives listed under the four established goals in the plan, and 3) the mitigation strategies that are developed subsequent to a federally-declared major disaster in Michigan lead to revised or new planning initiatives to be addressed in the plan.

Community Rating System – National Flood Insurance Program

An example of a FEMA program that is being used to fund the implementation of specific objectives is the Community Rating System (CRS), a voluntary incentive program under the National Flood Insurance Program that is being successfully implemented in Michigan by the Michigan Department of Environmental Quality. (The CRS recognizes and encourages community floodplain management activities that exceed the minimum NFIP requirements. Flood insurance premium rates are discounted to reflect the reduced flood risk resulting from the community actions.) Currently, 19 local Michigan communities participate in the CRS, and several more are due to be added during 2011 (see pages 167-168). Generally, each participating community has either prepared a flood mitigation or is actively working on a plan (in some cases as part of a county- or region-wide planning effort) and has undertaken other floodplain management activities related to public information and education enhancement, mapping and floodplain regulations, flood damage reduction, or flood preparedness. These community activities, in turn, help reduce future flood losses, facilitate a more accurate insurance rating for the community (based on actual risk), and promote awareness of the NFIP and floodplain management.

Federal Hazard Mitigation Grant Programs

The Hazard Mitigation Grant Program (HMGP), Flood Mitigation Assistance Program (FMAP), Pre-Disaster Mitigation Program (PDMP), Project Impact (PI), and the Repetitive Flood Claims Program (RFCP) have all been successfully used in the past to fund hazard mitigation projects listed in this plan or that originated in local plans. In fact, this plan and those local plans are the primary sources of the projects that are considered for funding under these programs. Other projects have been successfully funded under the annual Emergency Management Performance Grant (EMPG), and more recently under the various grant programs established under the Department of Homeland Security (DHS). Please refer to Attachment C, and to the section called "Mitigation Tools and Measures," for extensive information about these programs and projects.

Post-Declaration Hazard Mitigation Strategies

The post-declaration mitigation strategy process has also contributed to the development of this plan in that the issues, concerns, and opportunities identified in those strategies have led to revised or new objectives being added to the plan, and/or new projects to be funded under the various mitigation grant programs. Development of the post-event mitigation strategy necessarily focuses attention on the disaster and its initiating conditions during the short-term recovery period, when mitigation opportunities are available that might otherwise disappear as the long-term recovery process begins. The mitigation strategies were jointly developed by FEMA and the EMD/MSP (with input from other involved federal, state and local agencies) and are signed by both parties as a commitment to implement the strategy to the extent that resources and circumstances allow.

The mitigation strategies that were developed for Federal Disasters 0774, 1028, 1128, 1181, 1226, 1237, 1346, 1413, 1527, 1777, and 4121 are included in Attachment F to this plan and have been incorporated, where appropriate, into specific objectives listed under one or more of the four plan goals. (Prior to Federal Disaster 1181 in Michigan, states were required to develop a more formalized plan—in lieu of the shorter strategy document—in order to meet the requirements set forth in Section 409 of the Stafford Act. Relevant recommendations from Michigan Section 409 plans from Federal Disasters 0774, 1028 and 1128 have been incorporated as objectives under the appropriate mitigation goals in this plan.)

Since it can take some time for after-action reports and mitigation strategies to be developed after a disaster occurs, it is therefore important to have promoted and obtained a widespread awareness of hazard mitigation opportunities and their value during response and recovery efforts. Even if such awareness is only achieved among a portion of the involved responders, emergency managers, and crew leaders, the benefits gained are still notable and important for reducing or preventing future problems. For example, during disaster #1028 (the Northern Michigan Deep Freeze), broken water pipes that needed immediate replacement (a response action) were fortified with freeze-resistant properties so as to prevent future damage from that type of hazard. This was due to a recognition that simple restoration of the pipes would leave them vulnerable to breaks during the next freeze event.

Similarly, any hazard mitigation activities funded under Section 406 can also serve as recognized, documented examples of post-declaration hazard mitigation projects executed as part of a response/recovery phase of emergency management, because Section 406 provides funding for "mitigation measures in conjunction with the repair of the disaster-damaged facilities…performed on the parts of the facility that were actually damaged by the disaster." Michigan has had numerous (post-disaster/recovery) hazard mitigation projects funded under this source, the most recent of which involved those that were funded under disaster #4121 (which took place in 2013). Attachment C provides more information.

Cooperating Technical Partner Program (NFIP Floodplain Mapping)

The Michigan Department of Environmental Quality, Land and Water Management Division (MDEQ/LWMD) also provides works with local communities for which floodplain maps are being developed through its "Cooperating Technical Partner" (CTP) Program. Under the CTP Program, states and local communities with demonstrated resources and expertise are delegated the authority to review and publish National Flood Insurance Program (NFIP) studies without the need for further federal review. The state and local communities, as CTPs, may also process revisions to existing NFIP studies and then re-map the floodplain. Local community resources may include, but are

not limited to, gathering of field data, labor, funding, in-house information, and providing technical expertise to print the floodplain maps. The MDEQ/LWMD devotes staff time and technical expertise to develop hydraulic models and produce the NFIP reports and associated digital floodplain maps which are then made available on the MDEQ/LWMD and FEMA web sites. This information can provide the basis for the community's flood hazard mitigation planning and floodplain management efforts.

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Michigan Hazard Mitigation Plan: Risk and Vulnerability Assessments

General Development Process for the Hazard Analysis Section

Since the previous edition of the Michigan Hazard Mitigation Plan was completed and adopted in March of 2011, it was recognized that the 2014 update needed to allow more time for such a large plan to be reviewed by all relevant agencies and their subject matter experts. In order to solve this problem, the hazard analysis section was updated during 2011 and 2012. A period of three years is not particularly long when it comes to updating a plan that is more than 900 pages long, but since more than 400 pages of it is composed of the hazard analysis sections, and since a separate, updated edition of the Michigan Hazard Analysis (MHA) had not been completed since 2006, it was decided that both an update of this half of the MHMP as well as a new edition of the MHA could be accomplished at the same time, leaving quite a bit of remaining time available to update the remainder of the MHMP in time for its deadline in 2014. The inclusion of a full range of hazards—natural, technological, and human-related—was retained for the July 2012 MHA as well as the March 2014 MHMP. However, since nearly two years would have passed between the newest edition of MHA and the March 2014 MHMP deadline, additional updates were clearly necessary in the hazard analysis sections of this plan. These updates were successfully made during the 2013-2014 period, led by MSP/EMHSD staff but with input from other agencies and information sources. This process worked decently enough that an updated edition of the MHA is again planned for about half-way through the MHMP update cycle (currently three years, but ideally five years, if regulations are legislatively changed to allow more time for this work).

In 2011, the MHMP format was amended to allow a single, integrated document rather than the smaller core document (used previously) that then referred to various other publications and attachments. This format has been retained for the 2014 update. Various ways to improve the MHMP format were considered, especially regarding ways to have the state plan more closely resemble the required format for local plans (as a way to assist with making the development of local plans easier), but there was insufficient time (staff resources) available to bring these ideas to realization, in part because of the work needed for disaster 4121 in 2013, but also because of time needed to comply with new federal requirements to submit an annual Threat and Hazard Identification and Risk Assessment (THIRA) and State Preparedness Report (SPR), these latter two being found to be frameworks that were too artificial in their design to carry well into the extensive hazard analyses that have been cumulatively developing for more than 15 years in Michigan's planning documents—analyses that have proven useful over many years, at both a state and local level.

In addition to the process of MSP/EMHSD personnel's own review, research, and work upon the 2012 MHA and 2014 MHMP updates, months of outreach, feedback, information and material review was contributed by numerous partnering agencies and stakeholders. These have been documented in the preceding section of the plan, in the multi-page listing of "Input Agencies and Processes: 2014 Michigan Hazard Mitigation Plan Update." Rather than repeat that information, or the preceding "Section by Section Summary of Changes," this current section of the plan will instead provide, in narrative form, an overview of the philosophy, general process, and methods by which the coordinated efforts of these many contributors were integrated into the 2012 MHA and 2014 MHMP update.

There is always the necessity, in any major planning process, of having a core team that is responsible for compiling and assessing information, evaluating proposed changes, and doing the actual final editing of the resultant document. MSP/EMHSD personnel acted as that core team, while interagency oversight and input opportunities were maintained by the MCCERCC, and its hazard mitigation committee. Some of the earliest preparation for the 2014 MHMP update process came in the form of MCCERCC agency review (and networking to partner agencies) of the MHA sections in this plan. Progress on MHA and MHMP updates were reported at meetings of MCCERCC and its committees, as a periodic task with which the MCCERCC had been charged by the governor with a key role. MCCERCC members either directly reviewed, or identified known subject matter experts to review, the details of information and text within the hazard analysis and plan. Additional organizations were informed and provided with an opportunity to review and provide feedback on the 2014 MHMP, which had not been involved in 2011. These included the Michigan Climate Coalition and the (now more active) Silver Jackets group in Michigan. After the initial information process was presented by MSP/EMHSD planning staff at various meetings, carefully chosen personnel within MSP/EMHSD proceeded to follow up individually with the agencies that possessed relevant expertise, and additional contact persons

and subject matter experts were sought out among universities, authors, web sites, etc. when considered appropriate. For example, authorities from Michigan State University and the University of Michigan (Ann Arbor) were asked to review sections of the hazard analysis or to answer specific questions. Author and meteorologist Paul Gross again graciously agreed to review weather-related sections and new/revised text about recent and anticipated climate change impacts upon Michigan's hazards and vulnerabilities. Subject matter experts who were contacted by MSP/EMHSD were sent information about the hazards and sections of the plan that were considered to be most relevant to their expertise. Feedback took many forms, but most of the information received by MSP/EMHSD was in a form that directly related to specific changes that could be made to the existing text within the plan. For example, typed email responses or revised documents from sections of the MHA and MHMP. Changes in the state documents were made as soon as possible, so that a revised version of the amended section could receive as much further review as was possible before the plan's official expiration date at the end of March 2014. For the first time, popular online/wireless social media was used by MSP to publicize the MHMP update and refer readers to the EMHSD web site where draft materials could be reviewed and comments sent to the plan editing staff.

The initial focus upon technical details of the hazard analysis then shifted to an evaluation and review of larger sections within the plan, in consultation with the MCCERCC hazard mitigation committee. Finally, a full draft plan was distributed to MCCERCC and its hazard mitigation committee for their review and approval in March 2014. These sections were simultaneously provided to FEMA (and also available on two MSP/EMHSD websites). Thus, the input of various agencies since 2011 was gradually consolidated into successive refinements in the draft plan until, by March 2014, a full draft was able to be formally agreed to by the MCCERCC and found to have met the planning requirements stemming from the Disaster Mitigation Act of 2000. (Any feedback or corrections received too late to be a part of that process will nevertheless be retained by MSP/EMHSD as feedback for consideration under subsequent review and evaluation as the new planning cycle from 2014 to 2017 is entered.)

The reformatting of the hazard analysis portion of the 2014 plan, into a separate stand-alone document (EMHSD Pub. 103) will allow it to serve as an attachment to other state documents, most notably including the Michigan Emergency Management (response) Plan. Any feedback about the MHMP that was not able to be considered for the March 2014 update deadline, can help to refine subsequent documents that are closely related, without waiting until the (March 2017) end of the next MHMP planning cycle to be utilized. This is especially worth noting here since some of the feedback obtained in 2014 might be considered out-of-date by 2017, but any such feedback after the March publication of the 2014 MHMP update is still likely to be put to good use in 2015 (MHA), and through these related documents which are also overseen by many of the same MSP/EMHSD planning personnel who were involved in the development, research, writing, and editing of the MHMP.

The stakeholders for each hazard-specific section of the MHMP were defined in terms of their expertise in the hazard, or in hazard-related measures, activities, programs, and initiatives. Stakeholders included the "steward" agency or organization for the hazard in question within Michigan's government, or at a federal level, or in an associated non-governmental organization (or an academic institution). Most of Michigan's state departments were considered to be stakeholders. In some cases, a federal agency (e.g. U.S. Geological Survey) was identified as a stakeholder. There were also subject matter experts who were contacted in other agencies and academic institutions for information, advice, and recommendations during this process. In some cases, organizations had contributed to the plan without traditional interaction, by posting information upon a web site that provided the insight that was needed. Even in these cases, however, a valuable enough web page tended to eventually prompt MSP/EMHSD planning personnel to contact a representative at the organization for more insight or assistance in the sources, applications, and limitations of the data that had been provided online.

Most of the burdens placed upon the stakeholder/partnering agencies involved the review of previously-developed chapters about specific hazards. In many cases, the agency was already generally familiar with the material, due to its involvement as a stakeholder in previous MHMP planning cycles. In other cases, text was newly written or completely revised and therefore had to be considered afresh. The review of each section served to ensure that the basic tone, reasoning, direction, content elements, and implications of the analysis were generally sound, as well as to correct any specific factual or typographic errors, and to add new descriptions of hazard events. In some cases, new maps and data had to be supplied by these reviewing agencies. The emphasis was on an accurate presentation of the nature, scope, magnitude, and actual/potential impacts of each hazard upon Michigan, and means to guard against the hazard, including the identification of any programs or initiatives not already described in previous versions of the section.

Input was also accepted regarding recommendations to improve the organization of a section, or to try to seek a better methodological approach to the topic to the extent that time and resources allow in future updates. The most problematic section may still be that for the Invasive Species hazard, so a different approach may be sought for the next edition of the MHA.

Hazard analysis sections that were new (or completely revised) in the 2011 edition were able to be substantially improved in this 2014 edition. Several typographic and grammatical errors, for example, were corrected in the Celestial Impact section, and an expanded treatment of cyber-attacks was added to the Terrorism section. Tables compiling historical information from the National Climatic Data Center for each Michigan County were able to be added into the updated 2014 edition, and thus to inform the overall summary table at the start of the analysis, which compares different types of hazards in terms of their average annual impacts. Every section in this plan has had serious thought put into it, and will continued to be assessed for relevance and accuracy in the future. Unfortunately, due to staff changes involved around the 2006 MHA, and the lack of a precise footnoting system in earlier editions of this document, full citations for all information have not been possible. The format established for the core documents in the 1990s had included a full list of citations, but without footnotes to denote precisely which information each source was used for, it became impossible to keep track of which sources had become outdated as the years passed and numerous new editions were produced. In addition, by 2011 it had become clear that many information sources for recent hazard events were those recorded online in rapidly-changing or archived websites, which would rapidly become inaccessible—sometimes mere weeks after they had initially been accessed. The recent solution to these problems has been to include in each new update some references to the main information sources, while readers can make use of internet search engines to verify (if needed) details of various hazards listed in the event descriptions throughout the hazard analysis. It is common that for each event, several web articles may be found, some of which may differ in certain details. Again, if corrections or additions seem to be needed in any part of this document, feedback is welcome and should be sent to Mike Sobocinski at sobocinskim@michigan.gov (or by phone at 517-336-2053). Every page of the MHMP was reviewed, and numerous clarifying changes in wording were common, even in cases where the essential information remained the same since 2011.

In all cases, whether through the update of a pre-existing hazard section or the development of an entirely new section, the overall goal is for the document to provide a current, comprehensive, accurate, and balanced "portrait" of Michigan's hazards, and for the quality of the work to be as good as possible within the constraints of available staff time, agency resources, and existing expertise.

The overall update process, in one sense, started as soon as the previous edition of this plan had been completed, approved by FEMA, and adopted officially by the state of Michigan. Even as other types of work were undertaken, the relevance of the material in the MHMP would often be recalled and considered in the light of new information obtained through local plans, meetings, feedback and questions at workshops, presentations, etc. In addition, the plan review standards for the Emergency Management Accreditation Program (EMAP) were kept in mind for this MHMP update, since a renewal of Michigan's accreditation will be due before the next update of this plan in 2017. For example, the "consequence analysis" sections have been included for each hazard (e.g. impact of each hazard upon public confidence) and a special section related to this has also been updated with new survey information, in order to meet EMAP requirements as they stood in 2013.

Since several of the key MSP/EMHSD planning personnel on the core writing/editing team have also been involved in the production and review of Michigan's many local hazard mitigation plans, a knowledge of these local plans was able to be integrated into the expansion of the lengthy lists of historical incidents, the identification of which counties had identified particular hazards as locally most significant, and so on. (In turn, the new information and methods developed through this 2014 MHMP update will be shared with local planning and emergency management personnel as outreach, training, coordination, plan review, guidance, and direct assistance activities take place throughout the state during the 2014-2017 cycle of the MHMP.) This document has been designed to allow its text to be searchable by county name, therefore allowing the developers of local plans (or plan updates) to conveniently find all references to a specific Michigan county. In most Windows applications, using the "Ctrl" and "F" keys together will open up a search window ("Find…") and the name of the county can be typed into this window in order to locate all references that appear in this plan. Local planners are encouraged to make free use of this information in the development and update of the local hazard mitigation plans (or other types of relevant plans) they are working on.

Analysis of Michigan's Hazards for the 2014 MHMP Update: Format Used

As in the previous plan, the hazard analysis chapters instead now fit into three large sections according to their general classification as natural, technological, or human-related hazards. In some cases, hazards that are very closely related have some of their relevant features and mitigation strategies described in introductory material for an overarching section (e.g. thunderstorm hazards, hazardous materials) rather than solely within each of the most specific chapters (e.g. lightning, severe winds). A fairly consistent and consolidated organization of the information within each of its many chapters has been sought, and the largest change in this might be seen within the updated section on riverine flooding, which has now been made more consistent with this standard format than it had been in previous plans. The standard organization chosen for most (but not all) of the chapters involve the following subsections for each hazard (where enough research has accumulated to allow all of these sections to be developed and included): (1) Hazard Description, (2) Hazard Analysis, (3) Significant Historical Events, (4) Programs and Initiatives, (5) Mitigation Alternatives, and (6) Tie-In with Local Hazard Mitigation Planning. Each of these subsections is further described below, and is intended to help (A) clearly identify for FEMA and EMAP reviewers where to find each of the elements required under their plan review standards, and (B) to help move toward a similar or parallel formatting that the developers of local hazard mitigation plans may find convenient to use.

Hazard Description

Each hazard is describer in a manner that explains its nature to both the general public and to more specialized readers. Federal review standards under the Disaster Mitigation Act of 2000 require this element for all significant natural hazards, in hazard mitigation plans both at the state and the local level. Local developers of hazard mitigation plans (or those reviewing such a plan as part of an update process) may freely make use of these descriptions in their own plans. This type of original material, written specifically for the MHMP, is freely available for use by local governments, without concerns regarding copyright or permission. (In order to promote coordination between state and local plans, however, the local plan should include the fact that it made use of this MHMP during its development or review process, in compliance with a different federal requirement that the local plan describe the review and incorporation of existing plans.)

Hazard Analysis

The diversity of the hazards in this plan precluded a totally standardized approach to their analysis, but the hazard analysis for each chapter has tended to make use of the best available information to try to consider all of the aspects of each hazard that are most relevant, as well as to try to cover all of the FEMA risk assessment requirements and EMAP consequence analysis requirements. In addition to various vulnerabilities, each chapter tends to include the following:

(1) Location: For hazards that vary significantly in their impacts or frequency from one part of the state to another, the locations of these different risks tend to be analyzed either through the use of maps or tables or the detailed description of historical events. Some hazards have a longer history of occurrences than others, and the amount of detail that is conveniently available in known data sources is also quite variable. Some hazards are more amenable to spatial analysis than others. Nevertheless, one of the basic ideas for local planners, emergency managers, or plan reviewers to make note of is that this feature of the MHMP analysis typically allows a local analyst to peruse the plan for specific information about the county or region of the state for which a local plan must be made or reviewed. This element is required for both state and local plans to pass federal review, but the amount of local detail will naturally be greater in the local plans. Typically, the MHMP will describe geographic variation in hazards down to the county level, and the local hazard mitigation plans (which are typically produced by county-level emergency management programs) should provide location information down to the level of the minor civil division, the floodplain, or even specific sites, for hazards that are considered to be locally significant. This is especially important because a hazard (i.e. a small floodplain area) might be too small to show up on a state-level map, yet may result in disaster-level damages and harm.

(2) Probability/frequency of future events: For most hazards, the probability or frequency of future events is estimated from the recorded history of past significant events (see below). A probability may be very difficult to calculate, as in the engineering calculations that underlie the Flood Insurance Rate Maps which designate recognized flood areas that have a calculated 1% annual probability of reaching or exceeding a particular flood level. Since most persons do not have a great deal of training in probability theory, yet may have valuable information about area hazards that should be included in a plan, it is also acceptable to describe hazards in terms of their expected frequency. For example, snow falls every year throughout Michigan, which translates to an annual probability of 100%, but it is much more relevant to refer to the number of snowstorms per year in different areas, rather than leaving things with a simple statement that

every area does receive snow. In this way, differences between geographic locations can more meaningfully be assessed through the use of estimated frequencies of occurrence rather than probabilities, and the frequency of occurrence can easily be estimated through an ordinary mathematical procedure in which the number of significant hazard events is divided by the number of years in the historical records. For example, 50 snowstorms over a 10 year period results in an annual expected frequency of 5 snowstorms per year. (By definition, a "probability of occurrence" does not ever exceed 100%, and the mathematical procedures for estimating probabilities can quickly become complicated.) For a second example, if 10 tornadoes occur during a 50 year period, then the annual expected frequency of tornadoes is 0.5 or ½, which (taking the reciprocal) can also be expressed as about 1 event every 2 years, on average. In this way, all hazards can readily be compared with each other, but caution must be used before the risk from any hazard is declared to be "zero" if there are no recorded events in an area. Rather, a theoretical approach should be used to estimate the likelihood of events that could happen in an area, even if they haven't yet been observed there (e.g. terrorism). One might look at the history of similar areas in order to produce such an estimate. Various techniques like this have been employed throughout the MHMP, as considered appropriate for the consideration of each type of hazard. **The summary table at the start of the Hazard Analysis section provided the most convenient way to present this information.**

Technical note: Mathematically, a probability and a frequency differ significantly although esoterically from each other in various ways. The probabilistic concept of the "chance of occurrence" is more difficult to calculate and is more likely to be misinterpreted by non-specialist readers. For example, a "base flood" has a 1% chance of occurrence per year—a probability that has been calculated by engineers or scientists after expensive and time-consuming field measurements. Over a 100-year period, however, the cumulative chance of a flood occurring within that area is not 100%, as many laypersons might guess, but only 63.4%, due to the mathematical rules that apply to a sequence of conditional 0.01 probabilities over the course of 100 years: $1 - 0.99^{100}$. Similarly, one person may express a historical record of one event every 100 years as equaling a 0.01 chance of occurrence, but another person may try to use that same technique in a case where 200 wildfires had occurred over the same 100 years and wrongly state that wildfires have a 200% chance of occurrence—a value that violates the basic principles of a probability function, and the very definition of a probability. In addition, it is quite possible for a 0.01 probability flood to occur many times within a 100-year period, just as it is possible to occasionally get "lucky" and roll several "snake eyes" in a row on a pair of dice, or to flip a coin numerous times and have it land on "heads" every time. Rather than deal with the technical mathematical distinctions between these concepts and those involving conditional probabilities (often useful to determine cumulative likelihoods or combinations of events that each have different individual probabilities), probability functions (a graph whose analysis requires either specialized tables, computers, or the use of calculus), or the determination of algebraic inverse functions (to reverse the steps used in a probabilistic algorithm like the one used in the flood example above), the most straightforward means of describing these concepts is instead recommended—a frequency of occurrence in the form of the expected (average) number of hazard events per year.

(3) The extent (magnitude, severity, intensity) of the hazard: This element is required for the analysis in local hazard mitigation plans, but has also been included here. Not only is it vital for the analysis of many hazards, but will also provide at least some of the information that local plan reviewer or developers will need for their own plans. Where intensity scales (e.g. Enhanced Fujita) or intensity categories (e.g. advisories or warnings) have been defined by recognized authorities on a particular hazard, these helpful devices have been described in the MHMP.

(4) The impact of each hazard: This element is not only required for all local plans, but is also required by EMAP for a state-level plan to comply with its accreditation standards. Furthermore, an EMAP-compliant state must describe each hazard in terms of its impact upon (a) the public, (b) emergency responders, (c) continuity of operations including continued delivery of services, (d) property, facilities, and infrastructure, (e) the environment, (f) the state's economy, and (g) public confidence in state governance. Four of these requirements have been given their own specific subsections within the hazard analysis portion of the hazard chapters in the plan. Furthermore, a special section provides an overarching overview of the potential impact of Michigan's hazard upon public confidence in government.

Significant Historical Events

This component is required for both state and local plans, and not only provides sufficient detail to allow many local jurisdictions to use within their own plans, but also tends to include various impact, intensity, and location information.

Programs and Initiatives

Provides a useful guide for resources that could address or mitigate vulnerabilities identified in the hazard analysis.

Hazard Mitigation Alternatives

Another guiding step to lead readers and analysts into a consideration of possible mitigation activities that might be useful for the types of vulnerabilities described in the hazard analysis. In this edition of the MHMP, however, numerous listings have been removed if they seemed to not to be especially close to the "mitigation" phase of emergency management, as federally defined ("sustained action taken to reduce or eliminate long-term risk to people

and their property from hazards"). In effect, preparedness activities have been de-emphasized in order to more strongly suggest what types of projects are more likely to qualify for FEMA hazard mitigation funding.

Tie-In with Local Hazard Mitigation Planning

On the one hand, this section includes references to local hazard mitigation plans which have been reviewed by MSP/EMHSD personnel. On the other hand, useful advice is given to those involved in local-level planning. For more information about local hazard mitigation planning standards: http://www.fema.gov/hazard-mitigation-planning-resources.

Hazard Mitigation Alternatives

The identification of risks and vulnerabilities should lead planners directly to a consideration of various hazard mitigation alternatives that might be applied to improve the safety and security of residents, property, the environment, the economy, and quality of life. A hazard mitigation alternative is not the same as a project or specific action that will definitely be implemented. Rather, an alternative is one of a potential set of actions or strategies that will be evaluated and compared with each other. An evaluation process will involve more than one agency, will take into consideration feedback from the public, legal limitations, economic constraints, and so on. Usually, however, the eventual result is the identification of one or more specific actions that can (and should) be undertaken to improve conditions for all or part of the planning area. The introductory section of this plan gave an overview of various general types of hazard mitigation actions. After an extensive consideration of numerous hazards that can affect Michigan, this plan will later present an array of carefully selected hazard mitigation objectives, which have received multi-agency approval for their appropriateness and feasibility, cost-effectiveness, legal defensibility, and so on. But such specific objectives stemmed from a consideration of a variety of mitigation alternatives, both general and specific in nature.

In this subsection of the plan, an array of hazard mitigation alternatives is presented. Some of these alternatives (such as zoning decisions) are more appropriate for local implementation, and the state's role would be to try to promote the consideration of these hazard mitigation strategies in local hazard mitigation plans. Other alternatives (such as legislation) are more appropriate for implementation by state government. Some alternatives may involve the participation of multiple actors at different levels (local, state, and federal; public, private, and non-profit). An example of such a hazard mitigation idea could be an improvement in a local community's drainage infrastructure that obtains federal grant funds (administered by a state agency) and makes use of matching funds from a local community foundation, while providing benefits to downstream areas in the watershed region as well. These types of very specific projects usually stem from hazard the mitigation actions found in local hazard mitigation plans, which are usually produced in coordination with State and Federal agencies (the Michigan State Police Emergency Management and Homeland Security Division, and the Federal Emergency Management Agency).

Some portions of the following lists of mitigation alternatives also appear in later sections of this plan, but because there are some items that serve multiple functions in alleviating harm and risks from numerous hazards, an extensive list of alternatives is initially presented for here. The list was considered by planners at the state level, but is also intended for consideration by planners and emergency managers in regional and local jurisdictions.

Although "hazard mitigation" is often presented as if it is something entirely distinct from "preparedness, response, and recovery," (known together as the four phases of emergency management), and although one form of hazard mitigation is prevention, state planners in Michigan have usually opted not to try to place clear limits or distinctions around the hazard mitigation strategies listed here, since all phases of emergency management share the same ultimate goals of protecting life and property, etc. Many of the hazard mitigation strategies listed in state guidance documents may seem to include preparedness activities, and it has been widely recognized that many hazard mitigation activities can occur most easily during a period of recovery from a disaster (for example, rebuilding to a higher standard). However, the strategies now included here were selected from the broader lists previously published, in order to emphasize the kinds of activities that are closer to how FEMA has defined hazard mitigation, and thus to encourage more readers of this plan (and developers of local hazard mitigation plans) to have a better chance of recognizing and gaining FEMA grant eligibility for their project ideas. Additional activities may potentially help to save lives and protect communities and important agencies, beyond what are listed here as the ideas that are closer to "pure" hazard mitigation actions. After all, in the final selection of strategies for any hazard mitigation plan, care should be taken to ensure the inclusion of at least some strategies that are clearly hazard mitigation. That is, a "pure" hazard mitigation

strategy is an effort to prevent hazard impacts, or to take advance, proactive steps toward the long-term reduction of the impacts of hazards on a community. Some of these may take place during the response or recovery phases of a disaster, not just before an event (since no sooner does one event end than another one may begin, and therefore anything that is done is always potentially in advance of some future hazard event). The narrower, more specific view of hazard mitigation often does need to be taken into consideration, to meet certain grant eligibility requirements.

That being said, an extensive list of hazard mitigation alternatives is hereby presented for general consideration, and has been organized by hazard types, in approximately the same order that the hazards will be analyzed in later sections of this plan. Some hazards that are relatively new to this type of planning do not yet have a clearly established set of hazard mitigation strategies, but it is anticipated that this list will be refined in the future.

I. Natural Hazards

A. WEATHER HAZARDS

Thunderstorm Hazards (General)

- Increased coverage and use of NOAA Weather Radio.
- Public early warning systems and networks.
- Tree trimming and maintenance to prevent limb breakage and safeguard nearby utility lines. (Ideal: Establishment of a community forestry program with a main goal of creating and maintaining a disaster-resistant landscape in public rights-of-way.)
- Buried/protected power and utility lines. (NOTE: Where appropriate. Burial may cause additional problems and costs in case of breakage, due to the increased difficulty in locating and repairing the problem.)

Hail-specific (in addition to the General Thunderstorm Hazards list)

- Moving vehicles into garages or other covered areas.
- Inclusion of safety strategies for severe weather events in driver education classes and materials.
- Purchase of insurance that includes coverage for hail damage.
- Using structural bracing, window shutters, laminated glass in window panes, and impact-resistant roof shingles to minimize damage to public and private structures.

Lightning-specific (in addition to the General Thunderstorm Hazards list)

- Using surge protectors on critical electronic equipment.
- Installing lightning protection devices on the community's communications infrastructure.

Severe Winds and Tornadoes (in addition to the General Thunderstorm Hazards list)

- Using appropriate wind engineering measures and construction techniques (e.g. structural bracing, straps and clips, anchor bolts, laminated or impact-resistant glass, reinforced entry and garage doors, window shutters, waterproof adhesive sealing strips, and interlocking roof shingles) to strengthen public and private structures against severe wind damage.
- Proper anchoring of manufactured homes and exterior structures such as carports and porches.
- Securing loose materials, yard, and patio items indoors or where winds cannot blow them about.
- Construction of concrete safe rooms in homes and shelter areas in mobile home parks, fairgrounds, shopping malls, or other vulnerable public areas.

Winter Weather Hazards (General)

- Increased coverage and use of NOAA Weather Radio.
- Tree trimming and maintenance to prevent limb breakage and safeguard nearby utility lines. (Ideal: Establishment of a community forestry program with a main goal of creating and maintaining a disaster-resistant landscape in public rights-of-way.)
- Buried/protected power and utility lines, where appropriate.
- Establishing heating centers/shelters for vulnerable populations.

Ice and Sleet Storms (in addition to the General Winter Weather Hazards list)

- Home and public building design and maintenance to prevent roof and wall damage from "ice dams."

Snowstorms (in addition to the General Winter Weather Hazards list)

- Proper building/site design and code enforcement relating to snow loads, roof slope, snow removal and storage, etc.
- Agricultural activities to reduce impacts on crops and livestock.
- Pre-arranging for shelters for stranded motorists/travelers, and others.
- Using snow fences or "living snow fences" (rows of trees or vegetation) to limit blowing and drifting of snow over critical roadway segments.

Extreme Temperatures

- Organizing outreach to vulnerable populations during periods of extreme temperatures, including establishing and building awareness of accessible heating and/or cooling centers in the community, and other public information campaigns about this hazard.
- Increased coverage and use of NOAA Weather Radio.

B. HYDROLOGICAL HAZARDS

Riverine, Shoreline, and Urban Flooding

- Flood plain (and coastal zone) management – planning acceptable uses for areas prone to flooding (through comprehensive planning, code enforcement, zoning, open space requirements, subdivision regulations, land use and capital improvements planning) and involving drain commissioners, hydrologic studies, etc. in these analyses and decisions.
- Acceptable land use densities, coverage and planning for particular soil types and topography (decreasing amount of impermeable ground coverage in upland and drainage areas, zoning and open space requirements suited to the capacity of soils and drainage systems to absorb rainwater runoff, appropriate land use and capital improvements planning) and involving drain commissioners, hydrologic studies, etc. in these analyses and decisions.
- Dry floodproofing of structures within known flood areas (strengthening walls, sealing openings, use of waterproof compounds or plastic sheeting on walls).
- Wet floodproofing of structures (controlled flooding of structures to balance water forces and discourage structural collapse during floods).
- Elevation of flood-prone structures above the 100-year flood level.
- “Floating” architectural designs for structures in flood-prone areas
- Construction of elevated or alternative roads that are unaffected by flooding, or making roads more flood-resistant through better drainage and/or stabilization/armoring of vulnerable shoulders and embankments.
- Government acquisition, relocation, or condemnation of structures within floodplain or floodway areas.
- Employing techniques of erosion control within the watershed area (proper bank stabilization, techniques such as planting of vegetation on slopes, creation of terraces on hillsides, use of riprap boulders and geotextile fabric, etc.).
- Protection (or restoration) of wetlands and natural water retention areas.
- Obtaining insurance. (Requires community participation in the NFIP.)
- Joining the National Flood Insurance Program (NFIP). **VERY IMPORTANT!**
- Participation in the Community Rating System (CRS).
- Structural projects to channel water away from people and property (dikes, levees, floodwalls) or to increase drainage or absorption capacities (spillways, water detention and retention basins, relief drains, drain widening/dredging or rerouting, debris detention basins, logjam and debris removal, extra culverts, bridge modification, dike setbacks, flood gates and pumps, wetlands protection and restoration).
- Higher engineering standards for drain and sewer capacity, or the expansion of infrastructure to higher capacity.
- Drainage easements (allowing the planned and regulated public use of privately owned land for temporary water retention and drainage).
- Installing (or re-routing or increasing the capacity of) storm drainage systems, including the separation of storm and sanitary sewage systems.
- Farmland and open space preservation.
- Elevating mechanical and utility devices above expected flood levels.
- Flood warning systems and the monitoring of water levels with stream gauges and trained monitors.
- Increased coverage and use of NOAA Weather Radio.

- Anchoring of manufactured homes to a permanent foundation in flood areas, but preferably these structures would be readily movable if necessary or else permanently relocated outside of flood-prone areas and erosion areas.
- Control and securing of debris, yard items, or stored objects (including oil, gasoline, and propane tanks, and paint and chemical barrels) in floodplains that may be swept away, damaged, or pose a hazard when flooding occurs.
- Back-up generators for pumping and lift stations in sanitary sewer systems, and other measures (alarms, meters, remote controls, switchgear upgrades) to ensure that drainage infrastructure is not impeded.
- Detection and prevention/discouragement of illegal discharges into storm-water sewer systems, from home footing drains, downspouts and sump pumps.
- Employing techniques of erosion control in the area (bank stabilization, planting of vegetation on slopes, creation of terraces on hillsides).
- Increasing the function and capacity of sewage lift stations and treatment plants (installation, expansion, and maintenance), including possible separation of combined storm/sanitary sewer systems, if appropriate.
- Purchase or transfer of development rights – to discourage development in floodplain areas.
- Stormwater management ordinances or amendments.
- Wetlands protection regulations and policies.
- Use of check valves, sump pumps and backflow preventers in homes and buildings.

Dam Failures

- Regular inspection and maintenance of dams.
- Garnering community support for a funding mechanism to assist dam owners in the removal or repair of dams in disrepair.
- Regulate development in the dam's hydraulic shadow (where flooding would occur if a severe dam failure occurred).
- Ensuring that dams meet or exceed the design criteria required by law.
- Public warning systems.
- Obtaining insurance.
- Increased coverage and use of NOAA Weather Radio
- Increased funding for dam inspections and enforcement of the Dam Safety Program (Part 315 of the Natural Resources and Environmental Protection Act) requirements and goals.
- Constructing emergency access roads to dams, where needed.
- Pump and flood gate installation/automation.

Drought

- Storage of water for use in drought events (especially for human needs during periods of extreme temperatures, and for responding to structural fire and wildfire events).
- Legislative acts, local ordinances, and other measures to prioritize or control water use.
- Encouragement of water-saving measures by consumers (including landscaping, irrigation, farming, and low-priority lawn maintenance and non-essential auto washing).
- Anticipation of potential drought conditions, and the preparation of drought contingency plans.
- Designs, for recreational and other water-related structures and land uses, that take into account the full range of water levels (of lakes, streams, and groundwater).
- Designs and plans for water delivery systems that include a consideration of drought events.
- Obtaining agricultural insurance.

C. ECOLOGICAL HAZARDS

Wildfires

- Proper maintenance of property in or near wildland areas (including short grass; thinned trees and removal of low-hanging branches; selection of fire-resistant vegetation; use of fire resistant roofing and building materials; use of functional shutters on windows; keeping flammables such as curtains securely away from windows or using heavy fire-resistant drapes; creating and maintaining a buffer zone (defensible space) between structures and adjacent wild lands; use of the fire department's home safety inspections; sweeping/cleaning dead or dry leaves, needles, twigs, and combustibles from roofs, decks, eaves, porches, and yards; keeping woodpiles and other combustibles

away from structures; use of boxed or enclosed eaves on houses; thorough cleaning-up of spilled flammable fluids; and keeping garage areas protected from blowing embers).

- Safe disposal of yard and house waste rather than through open burning.
- Use of fire spotters, towers, planes.
- Use of structural fire mitigation systems such as interior and exterior sprinklers, smoke detectors, and fire extinguishers.
- Arson prevention activities, including reduction of blight (cleaning up areas of abandoned or collapsed structures, accumulated junk or debris, and lands with a history of flammable substances stored, spilled, or dumped on them).
- Public notification of fire weather and fire warnings.
- Prescribed burns and fuel management (thinning of flammable vegetation, possibly including selective logging to thin out some areas. Fuels cleared can be given away as firewood or made into wood chips for distribution.)
- The creation of fuel breaks (areas where the spread of wildfires will be slowed or stopped due to removal of fuels, or the use of fire-retardant materials/vegetation) in high-risk forest or other areas.
- Keeping roads and driveways accessible to vehicles and fire equipment—driveways should be relatively straight and flat, with at least some open spaces to turn, bridges that can support emergency vehicles, and clearance wide and high enough for two-way traffic and emergency vehicle access (spare keys to gates for properties should be provided to the local fire department, and an address should be visible from the road so homes can be located quickly).
- Enclosing the foundations of homes and buildings rather than leaving them open with their underside exposed to blown embers or materials.
- Safe use and maintenance/cleaning of fireplaces and chimneys (with the use of spark arresters and emphasis on proper storage of flammable items). Residents should be encouraged to inspect chimneys at least twice a year and clean them at least once a year.
- Proper maintenance and storage of motorized equipment that could catch on fire (from blown embers, etc.)
- Proper storage and use of flammables, including the use of flammable substances (such as when fueling machinery). Store gasoline, oily rags and other flammable materials in approved safety cans. Stack firewood at least 100 feet away and uphill from homes.
- Avoid building structures on hilltop locations, where they will be at greater risk from wildfires (in addition, hillsides facing south or west are more vulnerable to increased dryness and heat from sun exposure).
- Use of proper setbacks from slopes (outside of the "convection cone" of intense heat which would be projected up the slope of the hill as a wildfire "climbs" it).
- Have adequate water supplies for emergency fire fighting (in accordance with NFPA standards).
- Obtaining insurance.

Invasive Species

- Restrictions on the import and transport of species carriers.
- Adjustments to hunting, fishing, and other policies and regulations related to wildlife populations.
- Use of barriers to prevent invasive species travel.
- Use of competing species or other population control techniques.

D. GEOLOGICAL HAZARDS

Earthquakes – (the greatest Michigan threats would be to pipelines, buildings that are poorly designed or constructed, and the shelving, furniture, mirrors, gas cylinders, etc. within structures that could fall and cause injury or personal property damage)

- Adopt and enforce appropriate building codes.
- Use of safe interior designs and furniture arrangements.
- Obtain insurance.
- "Harden" critical infrastructure systems to meet seismic design standards for "lifelines."

Subsidence

- Identifying and mapping old mining areas and geologically unstable terrain, and limiting or preventing development in high-risk areas.
- Filling or buttressing subterranean open spaces (such as abandoned mines) to discourage their collapse.

- Hydrological monitoring of groundwater levels in subsidence-prone areas.
- Insurance coverage for subsidence hazards.
- Real estate disclosure laws.

Celestial Impacts

- Advance planning for catastrophic scenarios. For example, the U.S. Air Force used an asteroid strike for its December 2008 Interagency Deliberate Planning Exercise. The after-action report for that exercise was posted online at http://neo.jpl.nasa.gov/neo/Natural_Impact_After_Action_Report.pdf. An asteroid detected at a distance equivalent to that of the Earth's Moon could still give 8 hours of advance warning for the evacuation of coastal areas (to mitigate loss of life from a projected sea impact).
- Continued surveillance and analysis of Near-Earth Objects, and support for agencies that are engaged in such work. For example, since 1975, the Department of Defense has amassed extensive data about meteors entering the atmosphere, finding that hundreds per year explode in the atmosphere with explosive energy of at least 1 kiloton.
- Existing technologies would allow the diversion of a large asteroid or comet, if a sufficient lead time is available. Objects on a collision course 10 to 100 years in the future can be diverted or reduced by the use of conventional rockets and explosives. (Such action would be coordinated in the United States by the Departments of Defense and Energy, and would likely include international partners.) Explosives would require knowledge of an object's composition to be effective. Laser targeting could be used to change an object's velocity, although weeks or months may be required to obtain a large enough effect. With a sufficient amount of warning time (on the order of years), other mitigation techniques could include attaching a solar sail to the object, an interception/landing mission, and/or use of the "Yarkovsky effect" in which asteroid temperatures could be changed to affect its orbit.
- Various space missions have occurred to gather more information about asteroids and comets, and more are planned for the future. Some past missions have included Vega 1, Vega 2, Giotto, Suisei, and Sakigake (1986 flybys of Halley's Comet); Galileo (1995 observations of the Shoemaker-Levy comet impact); Near-Earth Asteroid Rendezvous (NEAR—asteroid investigations from 1997 to 2001); Deep Space 1 (comet rendezvous in 2001), Stardust (comet material collected and returned for analysis in 2006); Hayabusa (aka MUSES-C – asteroid landing and probing from 2005 to 2010); Rosetta (asteroid flybys from 2008 to 2010, and comet intercept mission scheduled for 2014-2015); and Deep Impact/EPOXI (comet rendezvous in 2005 and flyby in 2010). Additional missions can be expected to provide even more information.
- Awareness campaigns for industries and systems involving satellite communications, GPS, or radio communications that could be disrupted by solar flare (space weather) activity. In addition to the use of GPS for navigation, aviation, and military applications, it is also important for offshore drilling operations, precision farming, transportation, and mapping and surveying.
- Operating procedures that include back-up systems allowing complex systems (e.g. air traffic control) to continue to function when key technological systems (e.g. GPS, radio communications, satellites) malfunction. For example: the maintenance of "legacy" non-GPS navigational systems as a back-up, and the use of new GPS signals and codes to remove ranging errors.
- The use of special procedures, equipment, and redundancies by utility systems (e.g. electrical power and pipeline systems) to minimize the potential for geomagnetic effects to cause inappropriate shutdowns and system damage. For example: the provision of reserve capacity may offset the effects of geomagnetic storms, and the temporary disconnection of components for their own protection.
- Additional back-up satellites, for communications and navigation, will be needed to limit the damaging effects of a major solar storm, which may put current satellite equipment out of action and require their rapid replacements. The importance and cost of satellite systems may not be well-known to the general public. As of 2009, the existing fleet of 250 commercial satellites constituted a total investment of about $75 billion, and involved an annual revenue stream estimated at over $250 billion.

II. Technological Hazards

A. INDUSTRIAL HAZARDS

Structural Fires

- Code existence and enforcement.
- Designs that include the use of firewalls and sprinkler systems (especially in tall buildings, dormitories, attached structures, and special facilities).

- Landlords and families can install and maintain smoke detectors and fire extinguishers. Install a smoke alarm on each level of homes (to be tested monthly, with the batteries changed twice each year). Family members and residents should know how to use a fire extinguisher.
- Proper installation and maintenance of heating systems (especially those requiring regular cleaning, those using hand-loaded fuels such as wood, or using concentrated fuels such as liquid propane).
- Safe use and maintenance/cleaning of fireplaces and chimneys (with the use of spark arresters and proper storage of flammable items). Residents should inspect chimneys at least twice a year and clean them at least once a year.
- Safe installation, maintenance, and use of electrical outlets and wiring.
- Measures to reduce urban blight and associated arson (possibly including Crime Prevention through Environmental Design).
- Defensible space around structures in fire-prone wildland areas.
- Proper maintenance of power lines, and efficient response to fallen power lines.
- Transportation planning that provides roads, overpasses, etc. to maximize access and improve emergency response times to all inhabited or developed areas of a community. (Not just planning for average traffic volumes in the community.)
- Discourage civil disturbances and criminal activities that could lead to arson.
- Enforced fireworks regulations.
- Elimination of clandestine methamphetamine laboratories through law enforcement and public education.
- Condominium-type associations for maintaining safety in attached housing/building units or multi-unit structures.
- Obtaining insurance.

Scrap Tire Fires

- Policies for regulated disposal and management of scrap tires, and enforcement of regulations related to them (separation of stored scrap tires from other materials; limits on the size of each pile; minimum distances between piles and property lines; covering, chemically treating, or shredding tires to limit mosquito breeding; providing for fire vehicle access to scrap tire piles; training employees in emergency response operations; installation of earthen berms around storage areas; prevention of pools of standing water in the area; control of nearby vegetation; an emergency plan posted on the property; storing only the permitted volume of tires authorized for that site).
- Proper siting of tire storage and processing facilities (land use planning that recognizes scrap tire sites as a real hazard and environmental threat).
- Pest-control measures for mosquitoes and other nuisances around scrap tire yards.

Fixed Site Hazardous Material Incidents (including explosions and industrial accidents)

- Compliance with/enforcement of Resource Conservation and Recovery Act (RCRA) standards.
- Elimination of clandestine methamphetamine laboratories through law enforcement and public education.
- Identification of radioactive soils and high-radon areas
- Proper separation and buffering between industrial areas and other land uses.
- Location of industrial areas away from schools, nursing homes, etc.
- Public warning systems and networks for hazardous material releases.
- Increased coverage and use of NOAA Weather Radio (which can provide notification to the community during any period of emergency, including large scale hazardous material incidents).
- Compliance with all industrial, fire, and safety regulations.
- Insurance coverage.
- Enhanced security and anti-terrorist/sabotage/civil disturbance measures.

Hazardous Material Transportation Incidents

- Improved design, routing, and traffic control at problem roadway areas.
- Long-term planning that provides more connector roads for reduced congestion of arterial roads.
- Railroad inspections, maintenance and improved designs at problem railway/roadway intersections (at grade crossings, rural signs/signals for RR crossing).
- Proper planning, design, maintenance of, and enhancements to designated truck routes.
- Public warning systems and networks.

- Increased coverage and use of NOAA Weather Radio (which can provide notification to the community during any period of emergency, including large scale hazardous material incidents).
- Use of ITS (intelligent transportation systems) technology.
- Locating schools, nursing homes, and other special facilities away from major hazardous material transportation routes.

Pipeline Accidents (Petroleum and Natural Gas)

- Locating pipelines away from dense development, critical facilities, special needs populations, and environmentally vulnerable areas whenever possible.
- Increasing public awareness and widespread use of the "MISS DIG" utility damage prevention service (800-482-7171).
- Proper pipeline design, construction, maintenance and inspection.

Nuclear Power Plant Emergencies

- Arrangements for designated shelters and accident warning systems.
- Increased coverage and use of NOAA Weather Radio (which can provide notification to the community during any period of emergency, including plant accidents).

Oil and Natural Gas Well Accidents

- Using buffer strips to segregate wells, storage tanks, and other production facilities from transportation routes and adjacent land uses, in accordance with state regulations, and consistent with the level of risk.
- Adherence to all regulations and best industry practices, especially for relatively new techniques of hydraulic fracturing, in order to preserve Michigan's environmental quality and public confidence in the industry.

B. INFRASTRUCTURE HAZARDS

Infrastructure Failures

- Proper location, design, and maintenance of water and sewer systems (to include insulation of critical components to prevent damage from ground freeze).
- Burying electrical and phone lines, where beneficial and appropriate, to resist damage from severe winds, lightning, ice, and other hazards.
- Redundancies in utility and communications systems, especially "lifeline" systems; to increase resilience (even if at the cost of some efficiency).
- Separation and/or expansion of sewer system to handle anticipated stormwater volumes.
- Use of generators for backup power at critical facilities.
- "Rolling blackouts" in electrical systems that will otherwise fail completely due to overloading.
- Replacement or renovation of aging structures and equipment (to be made as hazard-resistant as economically possible).
- Physical protection of electrical and communications systems from lightning strikes.
- Tree-trimming programs to protect utility wires from falling branches. (Ideal: Establishment of a community forestry program with a main goal of creating and maintaining a disaster-resistant landscape in public rights-of-way.)
- Increasing public awareness and widespread use of the "MISS DIG" utility damage prevention service (800-482-7171).

Energy Emergencies

- Redundancies and alternatives in the energy supply system; provision of backup supply systems.
- The capacity to use more than one type of fuel to sustain necessary operations and functions.
- Use of alternative sources of energy (e.g. solar, wind sources) for key functions.
- Architectural designs that reduce the need for outside energy inputs.

Transportation Accidents

- Improved design, routing, and traffic control at problem roadway areas.
- Railroad inspections and improved designs at problem railway/roadway intersections (at grade crossings, rural signs/signals for RR crossing).

- Long-term planning that provides more connector roads for reduced congestion of arterial roads.
- Use of designated truck routes.
- Use of ITS (intelligent transportation systems) technology.
- Airport maintenance, security, and safety programs.

III. Human-Related Hazards

Civil Disturbances (prison or institutional rebellions, disruptive political gatherings, violent labor disputes, urban protests or riots, or large-scale uncontrolled festivities)

- Some suggest that design, management, integration, and lowered density of poor or blighted areas will reduce vandalism, crime, and some types of riot events. Crime Prevention Through Environmental Design (CPTED) is a field of planning that deals with this.
- Structure and property insurance in risky areas, combined with anti-arson practices.
- Design requirements for schools, factories, office buildings, shopping malls, hospitals, correctional facilities, stadiums, recreation areas, etc. that take into consideration emergency and security needs.

Nuclear Attack

- Designated fallout shelters and public warning systems.
- Construction of concrete safe rooms (or shelters) in houses, trailer parks, community facilities, and business districts.
- Using laminated glass, metal shutters, structural bracing, and other hazard-resistant, durable construction techniques in public buildings and critical facilities.
- Increased coverage and use of NOAA Weather Radio (which can provide notification to the community during any period of emergency, including enemy attack).

Public Health Emergencies

- Immunization programs to vaccinate against communicable diseases.
- Improving ventilation techniques in areas, facilities, or vehicles that are prone to crowding, or that may involve exposure to contagion or noxious atmospheres.
- Radon detection and abatement activities, to reduce concentrations of radon in homes and buildings.
- Maintaining community water and sewer infrastructure at acceptable operating standards.
- Providing back-up generators for water and wastewater treatment facilities to maintain acceptable operating levels during power failures.
- Demolition and clearance of vacant condemned structures to prevent rodent infestations.
- Free or reduced-expense community clinics and school health services.
- Brownfield and urban blight clean-up activities.
- Proper location, installation, cleaning, monitoring, and maintenance of septic tanks.
- Separation of storm and sanitary sewer systems.

Terrorism and Similar Criminal Activities

- Using laminated glass and other hazard-resistant, durable construction techniques in public buildings and critical facilities.
- Establishing avenues of reporting (and rewards) for information preventing terrorist incidents and sabotage.
- Consistent use of computer data back-up systems and anti-virus software.

- **SPECIAL SECTION: Consequence Analysis – Impact on Public Confidence in State Governance**

In late 2009 and early 2010, in order to meet additional planning requirements of the Emergency Management Accreditation Program (EMAP), contacts were made with representatives of the following agencies, who were considered to be potentially knowledgeable authorities on the subject of evaluating public confidence in governance:

Disaster Research Center (University of Delaware)
Institute for Public Policy and Social Research (Michigan State University)
National Opinion Research Center
Public Sector Consultants (Lansing, MI)
The Rand Corporation

Especially helpful was a discussion with Dr. Joe Trainor, of the Disaster Research Center. He reported that public confidence in government is rooted in the public's expectations of its government, and that this varies by community. (For example, more conservative political jurisdictions tend to have a greater sense of local independence, and correspondingly lessened expectations in State government.) There is an ongoing need to synchronize planning objectives with community expectations (especially in recovery operations, but also in response). This procedure typically involves the encouragement of consensus among stakeholders who disagree.

Since public expectations vary by community, information was sought concerning the variables that correlate with such expectations, and thus would also be expected to correlate with public confidence, and thus suggest something about how various hazards may affect such confidence. Andrew Morral, of the Rand Corporation, pointed out that negative impacts on public confidence in governance typically stem from gaps in response capabilities (as in the case of Hurricane Katrina).

Actual survey information is available for the State of Michigan, and its numerous regions. The Institute for Public Policy and Social Research, located at Michigan State University, conducts a "State of the State" survey (SOSS) four times per year. These scientific surveys include ongoing "tracking" questions that are asked regularly, as well as many specialized one-time questions designed to assess specific topics of current interest. Among the longitudinal questions (which can be assessed for change over time) are several that pertain to public confidence in government. The survey regularly asks separate questions about each level of government (local, state, and federal), and allows the responses to be analyzed for correlations and trends among 7 pre-defined survey regions as well as by the type of community that respondents live in (rural, small town, suburb, major city).

Longitudinal data was found for a 15-year period that included all SOSS surveys performed during the (full) years from 1994 to 2008. The overall survey has a reported margin of error of 3.1% (although error is larger for various individual cells within the tables used in this Plan Annex). Regional sampling data for each region were weighted to produce statewide figures. The various survey rounds each tended to cover a sample of between about 950 and 1450 Michigan adults. Additional information about the SOSS can be found at http://www.ippsr.msu.edu/SOSS . **The interpretations, analysis, and conclusions drawn from this survey data in this planning annex are solely those of MSP/EMHSD staff, and do not necessarily represent the ideas, views, or conclusions of Michigan State University or of IPPSR or its staff.** For the 2014 update of the MHMP, it was noticed that the same resources that had been accessed in 2010 were no longer readily available online. These would have been useful to simply replace previous tables and extend graph lines in this section of the MHMP, but instead, new information was able to be obtained in a matter that is described with new text and separate tables. Most of this new information supplements that which was obtained three years earlier, rather than replaces it. It is useful to compare trends in this kind of opinion data by viewing the most recent information in comparison with that from previous years.

In general, the public has more trust in government at the local and state level, and less trust in the federal level of government. The latest SOSS data (2012) on key questions regarding emergency management and trust in public governance reports that about 32% of Michigan respondents expressed the sentiment that the federal government can be trusted "seldom" or "almost never." Only about 22% expressed such an attitude about State government, and 19% about local governments. The survey used separate questions that distinguished between general trust in government and the respondents' assessment of specific public figures, such as the president and governor.

In 2010 longitudinal data, it was found that trust in state government was significantly lower in Detroit, where 31% expressed mistrust, compared to only 19% statewide at that time. The table on the next page shows the results obtained from the survey item which asked respondents, "How much of the time do you think you can trust the state government in Lansing to do what is right – nearly always or most of the time, some of the time, seldom, or almost never." Responses are presented in each row of the table, with separate columns (labeled along the top) that show how the answers varied across each of the seven survey regions of the state.

In addition to the lower trust expressed in the City of Detroit, the other statistically significant pattern found in the 2010 longitudinal table pertains to two other broad areas of the state: (1) the Upper Peninsula, and (2) the areas of the central and southern Lower Peninsula that are outside of the Metro-Detroit Regions. These areas were slightly more likely (a difference of only a few percentage points) to express a high level of trust in state government. Please note that this area does not include the northern Lower Peninsula region, which for survey purposes was considered to be composed of the 20 counties that are east and northeast of (but not including) Manistee County.

The SOSS analysis tables reprinted here are color-coded so that the most significant cell values are given darker shadings, and denote statistically significant correlations (either positive or negative). The standard used here for statistical significance is a Z-statistic that is greater than 2.0, which means that there is just over a 95% chance that the value in question does indeed vary significantly from the population as a whole (i.e. that it is "statistically significant"), rather than effectively being considered as approximately the same.

For readers who are not well-versed in statistical theory, it should be noted that statistical significance expresses a degree of reliability in measured survey data but not necessarily the strength, magnitude, or importance of the observed relationship. In other words, a high z score shows the extent of our confidence in the measurement, but the measurement itself may show only a very small demonstrated relationship between two variables. (For example, although we can state with certainty that a 1% income tax will lower a person's net income when it's deducted from a paycheck, this demonstrated relationship between that level of taxation and income may be small enough that many people might consider it to be of little concern, while for others it may be of enormous concern. Statistical significance means an estimate of the certainty that a relationship exists between measured variables, not the extent or importance of any such relationship, which is measured according to the extent of change seen in one variable as a result of some change in another.)

In addition, new information for 2012 has been found and included in the table on this page.

2012 SOSS Information about trust in different levels of government			
Trust in:	Federal government	State government	Local government
Nearly all/most of the time	19.5%	25.3%	39.5%
Some of the time	48.1%	52.4%	41.6%
Seldom	21.8%	15.5%	11.6%
Never	10.6%	6.8%	7.3%

How Often Trust State Government - Frequency Distribution, 1994-2008 Longitudinal Data File								
Cells contain: -Column percent -Z-statistic -N of cases	Source: MSU IPPSR SOSS (online data analysis run Feb. 2010)							
	1 Upper Peninsula	2 Northern Lower Peninsula	3 West Central L.P.	4 East Central L.P.	5 Southwest L.P.	6 Southeast L.P. (- Detroit)	7 Detroit	***ROW TOTAL***
1: NEARLY ALL OR MOST OF THE TIME	**32.5** 2.20 160	**27.2** -.58 207	**31.9** 4.09 652	**32.2** 3.39 403	**31.3** 3.39 634	**26.8** -3.15 1,782	**19.1** -7.73 258	***28.1*** --- *4,095*
2: SOME OF THE TIME	**49.1** -1.58 242	**50.7** -1.08 387	**51.7** -.86 1,058	**52.6** -.02 657	**51.9** -.70 1,053	**54.2** 3.40 3,596	**49.9** -2.13 673	***52.6*** --- *7,665*
3: SELDOM	**13.2** -.05 65	**15.6** 1.97 119	**11.4** -2.64 233	**10.8** -2.69 134	**11.6** -2.40 235	**13.2** .03 880	**19.5** 7.09 263	***13.2*** --- *1,928*
4: NEVER	**5.2** -.77 26	**6.5** .56 50	**5.0** -2.16 101	**4.4** -2.53 55	**5.3** -1.51 107	**5.8** -1.23 382	**11.6** 8.99 156	***6.0*** --- *876*
COL TOTAL	***100.0*** --- *492*	***100.0*** --- *763*	***100.0*** --- *2,045*	***100.0*** --- *1,248*	***100.0*** --- *2,029*	***100.0*** --- *6,639*	***100.0*** --- *1,349*	***100.0*** --- *14,565*
Means	1.91	2.01	1.89	1.87	1.91	1.98	2.24	1.97
Std Devs	.81	.83	.79	.77	.79	.79	.89	.81
Unweighted N	898	1,263	2,971	2,193	2,325	2,752	2,136	14,538

Color coding:	<-2.0	<-1.0	<0.0	>0.0	>1.0	>2.0	**Z**
N in each cell:	Smaller than expected			Larger than expected			

Expressed trust in state government was also analyzed with respect to the type of community in which respondents lived. The results of this analysis, for 2010 longitudinal data, appear in the table on the following page. Although higher levels of distrust were expressed within urban areas, collectively, this is actually explained by the inclusion of the City of Detroit within the "Urban Community" category, for when the data are further broken down while controlling for community type, respondents in urban communities in all other regions outside of Detroit expressed below-average levels of distrust. Since 41% of all "Urban Community" respondents were from Detroit, the greater proportion of dissatisfaction among Detroit responses pulled down the numbers for urban residents as a category. It should be kept in mind, however, that far fewer than half of all respondents, in any combination of these categories, stated that they seldom or almost never trusted state government. The analysis merely identifies varying proportions of distrust between state regions.

These types of analytic breakdowns of the level of trust by community and region were not conveniently available for use in the data available to update this plan in 2014. Later inquiry with IPPSR may be needed to provide that level of detail for later updates of this analysis, but these specific issues are already a bit abstracted from the main question of how emergency management or disasters might affect public confidence in governance. The attempt to establish some plausible reason to account for trends in trust or mistrust (the closest survey information available to express "confidence") will be addressed in subsequent pages in this section.

How Often Trust State Government - Frequency Distribution, 1994-2008 Longitudinal Data File						
	Source: MSU IPPSR SOSS (online data analysis run Feb. 2010)					
Cells contain: -Column percent -Z-statistic -N of cases	1 RURAL COMMUNITY	2 SMALL CITY OR TOWN, VILLAGE	3 A SUBURB	4 URBAN COMMUNITY	7 OTHER	***ROW TOTAL***
1: NEARLY ALL OR MOST OF THE TIME	**28.8** 2.04 953	**28.4** 1.60 1,193	**26.3** -1.64 807	**25.7** -1.89 471	**17.6** -2.65 25	***27.5*** --- *3,449*
2: SOME OF THE TIME	**52.5** -.47 1,736	**50.5** -3.80 2,121	**57.6** 6.08 1,766	**50.6** -2.06 929	**57.3** 1.08 83	***52.8*** --- *6,634*
3: SELDOM	**13.7** .31 454	**14.1** 1.20 592	**11.7** -3.38 360	**14.7** 1.55 270	**18.9** 1.89 27	***13.6*** --- *1,702*
4: NEVER	**4.9** -3.26 164	**7.1** 3.22 298	**4.3** -4.79 132	**9.0** 5.59 165	**6.1** -.01 9	***6.1*** --- *768*
COL TOTAL	***100.0*** --- *3,306*	***100.0*** --- *4,203*	***100.0*** --- *3,065*	***100.0*** --- *1,834*	***100.0*** --- *144*	***100.0*** --- *12,553*
Means	1.95	2.00	1.94	2.07	2.13	1.98
Std Devs	.79	.84	.74	.87	.77	.81
Unweighted N	3,703	4,300	2,191	2,168	140	12,502

Color coding:	<-2.0	<-1.0	<0.0	>0.0	>1.0	>2.0	**Z**
N in each cell:	Smaller than expected			Larger than expected			

What might be some reasons for distrust in government, where it exists? Perhaps some clues can be found in the survey questions that ask respondents about the "most important problem" facing their local community, the most important problem for the State governor and legislature, and the "overall quality of life" in their community. As the table on the following page shows, Detroit also stands out as being more frequently assessed as having "fair" or "poor" overall quality of life. The only other areas with (statistically significant) critical or ambivalent opinions on this topic were small cities/towns in the nearby Metro area (who had a slightly higher proportion, 7%, responding "poor"), and suburban respondents in the East Lower Peninsula region (who had a relatively high percentage, 42%, responding "fair"). Please note that these types of more detailed multivariate analysis have not been included in this document, which only includes a few of the most relevant two-variable cross tables obtained from this information source in 2010 (supplemented where possible with readily available 2012 survey information).

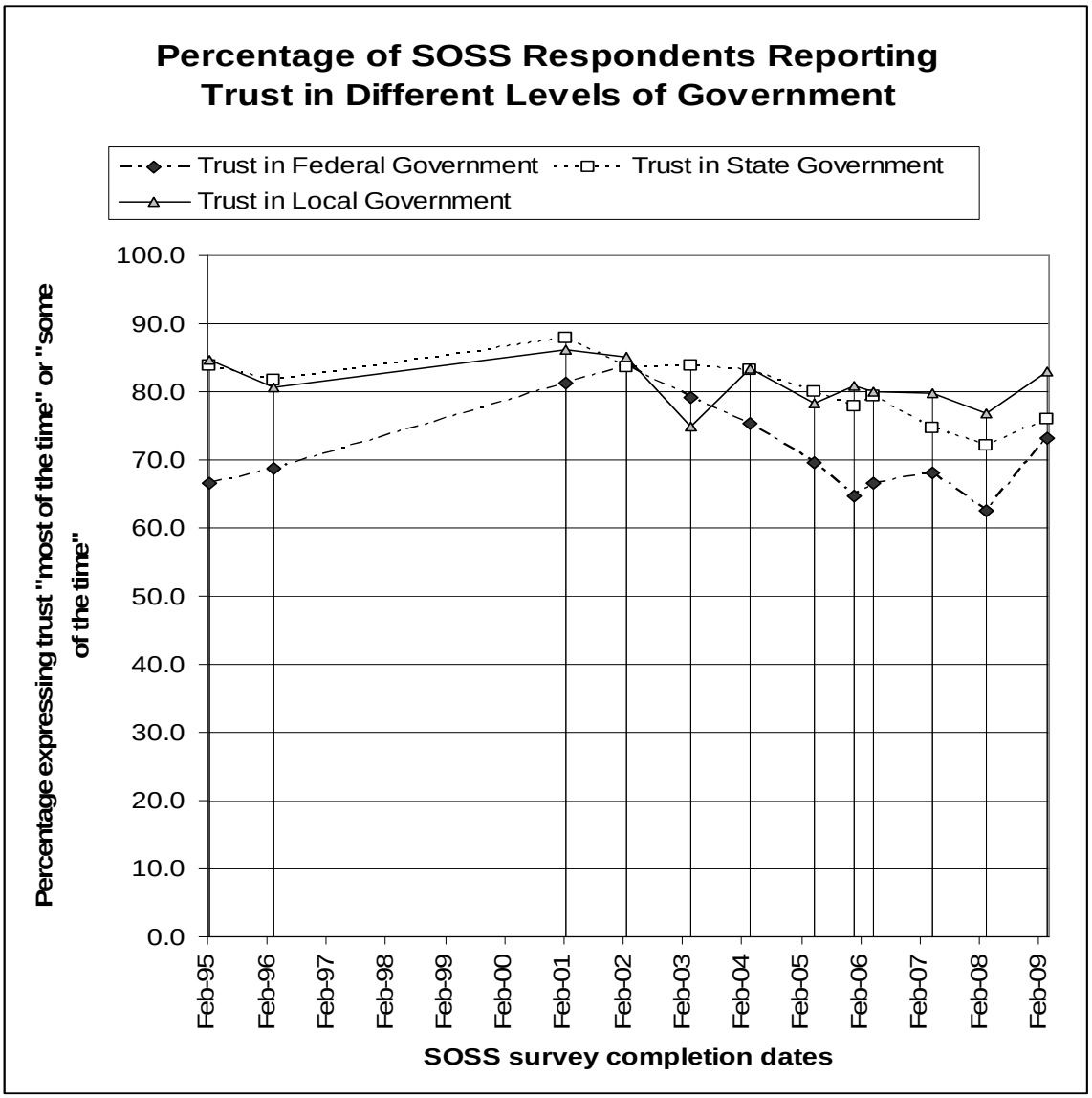
NOTE: 2012 survey results for the quality of life question were readily available for the total column <u>only</u> (in the far right side of the following table) and were found to be unchanged from the 2010 longitudinal results.

Overall Quality of Life In Community - Frequency Distribution, 1994-2008 Longitudinal Data File								
Cells contain: -Column percent -Z-statistic -N of cases	Source: MSU IPPSR SOSS (online data analysis run Feb. 2010)							
	1 Upper Peninsula	2 Northern Lower Peninsula	3 West Central L.P.	4 East Central L.P.	5 Southwest L.P.	6 Southeast L.P. (-Detroit)	7 Detroit	***ROW TOTAL***
1: EXCELLENT	**17.8** -.06 30	**22.1** 1.76 56	**19.5** 1.13 133	**19.8** 1.05 84	**13.0** -3.60 89	**20.6** 4.40 461	**6.3** -6.86 30	***17.9*** --- *883*
2: GOOD	**57.4** .30 96	**53.1** -1.02 135	**59.3** 1.75 405	**55.4** -.35 236	**63.0** 3.83 431	**59.0** 3.57 1,322	**30.6** -11.75 143	***56.2*** --- *2,769*
3: FAIR	**23.0** .36 39	**20.1** -.69 51	**18.7** -2.20 128	**22.7** .43 97	**21.6** -.22 148	**17.1** -7.48 382	**50.0** 15.46 233	***21.9*** --- *1,078*
4: POOR	**1.8** -1.43 3	**4.7** .60 12	**2.6** -2.02 18	**2.1** -2.10 9	**2.4** -2.20 17	**3.4** -1.88 76	**13.1** 10.62 61	***4.0*** --- *195*
COL TOTAL	***100.0*** --- *168*	***100.0*** --- *254*	***100.0*** --- *684*	***100.0*** --- *426*	***100.0*** --- *685*	***100.0*** --- *2,241*	***100.0*** --- *467*	***100.0*** --- *4,925*
Means	2.09	2.07	2.04	2.07	2.13	2.03	2.70	2.12
Std Devs	.69	.78	.69	.71	.65	.71	.77	.74
Unweighted N	314	394	1,013	747	789	925	745	4,927

Color coding:	<-2.0	<-1.0	<0.0	>0.0	>1.0	>2.0	**Z**
N in each cell:	Smaller than expected			Larger than expected			

Assessing levels of government trust over time may provide some additional insight on possible connections between hazards, vulnerabilities, and public confidence. We might expect that variations in public trust would occur after major disaster or emergency events, if such conditions really do have a major impact on public trust in government. The graph on the following page shows how public trust in three levels of government have varied over time, as assessed by SOSS surveys. Most of the time, there was a lower level of trust in federal government than there was in state or local government, but in survey responses following the events of 9-11-2001, trust in federal government was at a peak, equivalent to the other two levels of government, before dropping down again. A lower point followed the Hurricane Katrina and Rita events. These trends may be purely circumstantial, however, and not actually have been caused by those events—more scrutiny of the data would be necessary to try to draw any specific conclusions of that type. But it may be possible to use this survey data and analyze it to see whether certain types of local or state disaster events were followed by a drop in public trust. In the current assessment, the concerns identified by respondents will be focused upon.

NOTE: As shown in a preceding table, new 2012 data was found for this information, and these latest numbers show a 67.6% level of trust in federal government, 77.7% trust in state government, and 81.1% trust in local government. This information extends the data already presented in the 2010 graph on the next page.



Updated 2012 SOSS data were also obtained about the types of issues respondents felt were the most significant problems that needed to be addressed, and these have been compared with the information that was available in 2010 (actually surveyed in 2008) for the previous edition of this plan. Community problems most commonly identified by respondents (statewide) included:

2012	2008	
32.8%	20.8%	Unemployment/jobs/young people lack good jobs
12.9%	17.2%	Crime, drugs, gangs, teen violence, safety, street violence, theft (Respondents in the City of Detroit were more likely to select these problems, except for the "gang" and "teen violence" phrasing, which was more often reported by respondents in the broader Metro area.)
8.8%	10.2%	School finance/quality, education funding, similar education topics
9.2%	8.4%	Development, growth, economy, loss of businesses
4.9%	5.8%	Miscellaneous other problems
3.4%	4.5%	Roads: need repair, street upkeep
3.0%	4.2%	No problems
2.4%	3.3%	Overexpansion/growth, population growth, land use, preservation of wetland and natural areas
3.3%	3.2%	Taxes, city taxes, city finances, city commissioners

Most identified problems have declined over the past few years, replaced with a huge jump in the unemployment problem.

Some of these topics, such as crime, roads, and land use and environment, have relevance to Michigan hazard mitigation topics. Some less-frequently selected topics that also have relevance to hazard mitigation include:

2012	2008	
1.5%	2.1%	Water/sewer, trash collection, police/fire services
1.2%	1.7%	Traffic, transportation, buses, etc., other public services
1.1%	1.6%	Pollution, dirty city appearance, junk lying around, other environmental

When asked to identify the most important problem for the State Governor and legislature, respondents most frequently selected the following:

2012	2008	
26.6%	17.7%	Jobs, unemployment, employment, more work, etc.
18.6%	22.9%	Education, schools, school financing & funding
13.0%	12.4%	The economy, business in state, encourage business growth
6.2%	6.9%	Health care, medical care, mental health, etc.
5.1%	6.6%	Crime, safety, drugs, violence, law & order, prisons
4.5%	5.4%	Taxes, property taxes, etc.
4.6%	5.1%	(Miscellaneous)

In addition to crime & safety, some of the less frequently selected topics that are of relevance to hazard mitigation planning include:

2012	2008	
2.6%	3.2%	Roads, highways, bridges (repairs, maintenance)
2.2%	2.6%	Environment, clean-up, pollution control, etc.
0.5%	0.6%	Foreign policy, world affairs, defense (Note: Responsibility for these affairs is usually assigned to federal government.)
0.1%	0.1%	Infrastructure of cities

It must be noted that the recent winter weather of 2013-2014 has caused a rapid breakdown of roadway quality across the state. It is safe to say that the survey information in this section does not reflect the true current concern with the widespread poor condition of local surface streets, roads, and highways.

Books and documents recommended by Joe Trainor (of the Disaster Research Center) had produced the following additional information. A chapter in the Handbook of Disaster Research stated that the public envisions disaster recovery in terms of a return to "normalcy," while administrators, planners, and other experts instead wish to emphasize changes, which include improvements and hazard mitigation. A "sustainable development" approach to disaster recovery thus requires public involvement, effective pre-disaster planning, and a focus on equity. Recovery activities should meet local needs, match local capabilities, and, where possible, be rooted in effective recovery plans.

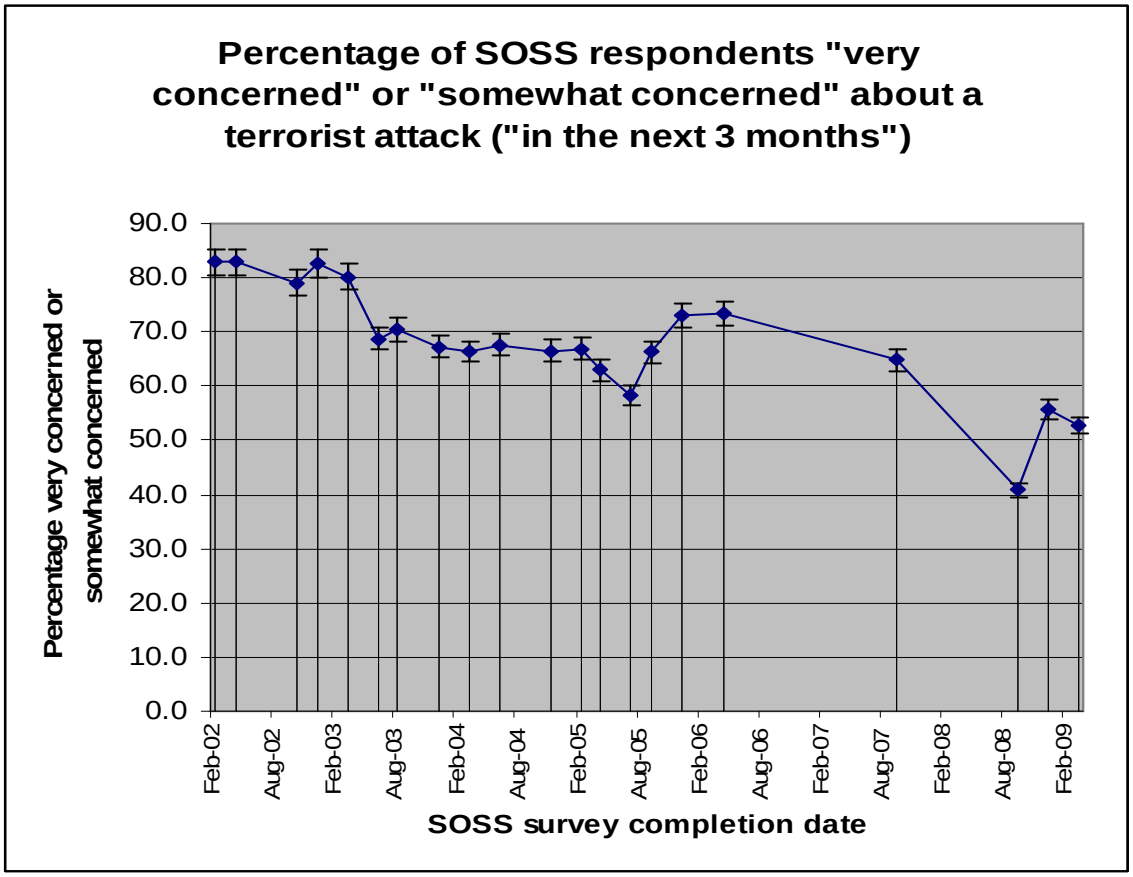
In the light of all this information, it does not appear that disasters have played much role in shaping residents' trust in Michigan government, although national circumstances (e.g. Hurricane Katrina) have suggested that it is indeed possible for such events to have a significant influence. Economic and political problems seem to be more directly connected with public confidence in government, and even though disasters can have economic impacts, Michigan's vulnerability has been rather limited, and the trends seen in the most recent survey data about these matters suggest a relative reduction in the amount of concern, in the face of economic/employment issues. One of the survey questions (Winter 1995) asked respondents whether the most important problem they had identified is something that should be addressed by government, by voluntary/community organizations, by business, or by people themselves. About 34% said government should address the problem. Although this was the most common of all the answers, as categorized (followed by "people themselves," with 32%), it needs to be noted that the idea was still expressed by a minority of respondents. The majority felt that non-governmental solutions were better, or that a combination of multiple entities should work together.

Issues such as crime and the environment were highlighted in the various editions of SOSS, but since only certain types of crime and environmental issues are potential disaster situations, most of the details of those surveys will not

be addressed here. However, in the Winter 1996 survey, 51% of respondents felt that the government was doing too little to protect the environment (while 38% felt it was doing about the right amount). About 57% felt it was very important to have environmental information, but 47% felt that it was somewhat difficult or very difficult to obtain accurate information about the subject. Although questions on this topic were not repeated in any later survey, it may be assumed that the availability of information on this topic has increased greatly since the rise of the internet (which was at the time being cited as a main source of information by fewer than 1% of respondents).

One of the specific hazards that was tracked by the SOSS surveys was the issue of terrorism and nuclear attack. In the Spring of 1999, when respondents were asked how much the development of atomic weapons in Pakistan and India may affect the well-being of persons in the United States, 58% responded "a great deal" and 30% responded "somewhat." When respondents were asked about the extent of American interests in the Middle East, 59% stated that these interests were "very significant," and 35% said "somewhat significant."

After the events of 9-11-2001, many additional questions were asked to gauge public opinion and attitudes toward various aspects of terrorist threats and activities. One of the questions included regularly in the survey each year asks respondents to express how much concern they have about another terrorist attack, and the likelihood that such an attack may affect Michigan or some other location in the United States. Overall (across all SOSS surveys), about 20 percent of respondents said that they were "very concerned" that "the United States might suffer another terrorist attack in the next 3 months," and another 43 percent said that they were "somewhat concerned." The level of concern has varied over time, as shown in the graph below, which shows the percentage of SOSS respondents who were either "very concerned" or "somewhat concerned" about a terrorist attack "in the next 3 months" following their dates of response. New 2012 data shows that this percentage has increased a bit from the 2009 figure shown in the table, at 61.7%. Given that the attempted airliner bombing as it flew near and over Detroit had taken place in Michigan at the end of 2009, this increased level of concern is not at all surprising. Recent state and national events involving shootings (near I-96, Sandy Hill Elementary) and bombings (e.g. Boston Marathon) can be expected to increase concern still further within the past couple of years since the 2012 data were collected.



A 3% margin of error is marked for each data point on the graph. Data points that appear within the range marked by these lines cannot with much confidence be considered to differ significantly from each other. It can easily be seen that concern was much higher during the period immediately following the events of 9-11-2001 (and subsequent anthrax scares). By mid-2003, however, a lower degree of concern had become evident but remained quite stable for a couple of years. A minor dip is suggested by the mid-2005 survey results, but levels of concern were a bit higher by 2006. Concern was substantially lower again by mid-2008 but did not seem particularly stable in recent years, based on the most recent survey results.

It seems reasonable that concern would decline over time if there are no significant events that remind people of a threat or vulnerability, and that may be the case here. The rise in concern after mid-2005 may have been caused by the July 7, 2005 London subway and bus bombings. The years 2005 and 2006 also marked a peak in terrorist casualties in Iraq, which were given a great deal of media attention and, despite their geographic remoteness from U.S. domestic security affairs, may have reminded the public of the terrorist threat. The lower concern expressed in 2008 may have subsequently been elevated by the Mumbai hotel attacks of November 8, reflected in the subsequent survey results.

This discussion brings back the question of what effect these types of hazards may have had on the public's trust in government. One question that was asked repeatedly involved the amount of responsibility that the United States bears "for the hatred that led to the 9/11 terrorist attacks." Overall (not breaking the results down by year, but according to 2010 the longitudinal search), 59.4 percent of respondents expressed the opinion that the United States either bears "a lot" of responsibility, or "some" responsibility, while 40.5 percent stated that the United States bears only "a little" responsibility, or "none at all" for the events that occurred that day.

Despite this, when respondents were specifically asked, in early 2002, to "rate the job the U.S. government is doing defending Americans at home from future terrorist attacks," 76.1 percent responded with either "excellent" or "good." (21.4% said "fair" and only 2.5% said poor.) Respondents were similarly asked to assess the job that the State of Michigan was doing, and 62.9 percent said either "excellent" or "good" (with only 6.7% saying "poor). In 2005, the assessment had fallen, with 50.8% of respondents saying "excellent" or "good."

Another 2002 survey asked respondents how much confidence they had in "the ability of the U.S. government to prevent further terrorist attacks against Americans in this country," and 58.4% of respondents said either "a great deal" or "a good amount" of confidence. (35.5% said "only a fair amount," while only 6.1% said "none at all.") Survey results on these questions obtained later in 2002 showed a slight decrease (54.1%) in such confidence. A re-worded 2004 question asking how well the federal government has prevented or prepared "for the possibility of another terrorist attack" resulted in 53.6% responding "excellent" or "good" and 16% saying "poor," and a similar 2005 question resulted in only 48.6% of respondents selecting "excellent" or "good."

In 2002, respondents were also asked how well prepared they think that their state and local governments are for a potential terrorist attack in Michigan. "Very prepared" was reported by only 8.6%, but 67% said "somewhat prepared," and only 5.9% said "not prepared at all." When asked specifically about state and local preparedness for a potential bio-terrorist attack, the results were slightly less confident (6.5% "very prepared," 60.6% "somewhat prepared," 22.4% "not very prepared," and 10.6% "not prepared at all.") Most respondents felt that neighborhood watch groups and utility service workers (meter readers, repairmen, etc.) should play some role in helping to identify potential terrorists. Most respondents also felt there was a role to be played by "special citizen patrols created solely for the purpose of looking for suspicious activity" in the neighborhood.

Follow-up questions in 2004 revealed that 51.1% of respondents felt that the ability of terrorists "to launch another major attack on the U.S." had lessened over the previous year (while 15.9% thought it had strengthened and 33% felt it was about the same). Most respondents in 2005 felt that Detroit was a less likely target for terrorism than Los Angeles, but 20.5% felt that it was "very likely" or "somewhat likely" that a terrorist attack would occur somewhere in the state over the following year. When the same respondents were asked to estimate the likelihood of a terrorist attack somewhere in the United States during the following year, 69.2% said "very likely" or "somewhat likely." Most respondents felt that terrorists preferred high-profile targets rather than random targets that would merely promote a sense of chaos and fear. Respondents preferred (80% versus 20%) that anti-terrorist funding be distributed based upon the geography of higher-profile targets, rather than assigned equally to each of Michigan's counties.

In advance of the following large section that gives a full analysis of Michigan's hazards, this short subsection provides definitions for various terms that will be relevant throughout this plan.

Selected Hazard Mitigation Definitions

ACQUISITION/RELOCATION: A voluntary program offered through the Hazard Mitigation Grant Program (HMGP), Flood Mitigation Assistance Program (FMAP), Pre-Disaster Mitigation Program (PDMP), Repetitive Flood Claims Program (RFCP), and Severe Repetitive Loss Program (SRLP) where repetitively flooded structures may be acquired by a municipality in order to remove the structure from the floodplain. The property owner is given pre-flood fair market value for the property. The municipality then clears the property of the structure and maintains the property as open space in perpetuity. The State is the administrator of the grant throughout this process and monitors the municipality in maintaining this property as open space.

ASSISTANCE: Any form of federal grant to implement cost-effective mitigation measures that will reduce the risk of future damage, hardship, loss, or suffering as a result of major disasters.

BASE FLOOD: That flood having a one percent chance of being equaled or exceeded in any given year. Commonly called the "100-year" flood.

COMMUNITY: Any state or area or political subdivision thereof, or any Indian Tribe or authorized tribal organization, or Alaska Native Village or authorized native organization which has authority to adopt and enforce floodplain management regulations for the areas within its jurisdiction.

COUNTY OR LOCAL EMERGENCY MANAGEMENT COORDINATOR: A person appointed pursuant to Act 390, P.A. 1976, as amended, to coordinate emergency management activities for a county or municipal emergency management program. Also commonly called County or Local "Emergency Manager."

DAMAGE ASSESSMENT: The systematic process of determining and appraising the nature and extent of the loss, suffering, or harm to a community resulting from an emergency/disaster.

DISASTER FIELD OFFICE (DFO): The location established within the disaster area that functions as the joint federal-state center for all response and recovery activities.

DISASTER MITIGATION ACT (DMA) OF 2000: Public Law 106-390, signed into law on October 30, 2000, which amended sections of the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act) and placed new hazard mitigation planning requirements on states and local governments in order to obtain Stafford Act disaster relief assistance.

DISASTER RECOVERY CENTER (DRC): A location established within the disaster area that functions as a "one-stop" information source for disaster recovery and hazard mitigation-related issues. DRCs are staffed by personnel from FEMA and other Federal agencies, state and local agencies, and private, voluntary relief organizations.

DISTRICT COORDINATOR: The Michigan State Police Emergency Management and Homeland Security Division employee serving at any of eight State Police District Headquarters, whose primary job is to work directly with local communities on emergency management activities.

DRY FLOODPROOFING: Any combination of adjustments and/or additions to structures that are intended to eliminate or reduce the potential for flood damage by preventing water from entering the structure. (Examples: waterproof walls and floors; permanently or contingently seal doors, windows, or other openings; build a berm higher than the floor level.)

ELEVATION: A voluntary program offered through the HMGP, FMAP PDMP, RFCP, and SRLP to raise the first floor of a structure at least one-foot above the recorded base flood ("100-year") elevation. Utilities can also be raised to reduce damage to structures.

EMERGENCY MANAGEMENT AND HOMELAND SECURITY DIVISION (MSP/EMHSD): The division within the Department of State Police that coordinates the comprehensive emergency management activities (mitigation, preparedness, response and recovery) and homeland security activities of state and local government and maintains the Michigan Emergency Management Plan and Michigan Hazard Mitigation Plan. The Emergency Management and Homeland Security Division is also the primary state coordinating agency for the HMGP, FMAP, PDMP, RFCP, and SRLP, and serves as the administrative arm of the Michigan Citizen-Community Emergency Response Coordinating Council (MCCERCC).

ENVIRONMENTAL ASSESSMENT: A document that is prepared when an HMGP, FMAP, PDMP, RFCP, or SRLP project does not qualify as a categorical exclusion and serves to determine whether an Environmental Impact Statement is needed.

ENVIRONMENTAL IMPACT STATEMENT: A document that is prepared for all actions significantly affecting the environment.

EXECUTIVE ORDER 1977-4: A Michigan Executive Order issued by Governor William G. Milliken on May 13, 1977 that 1) designated an administering state agency for the state flood hazard management program, 2) directed state agency directors to prevent uneconomic uses and the development of the State's floodplains, and 3) directed state agency directors to reduce the risk of flood losses in connection with state lands and installations and state financed or supported improvements. This Executive Order is still in effect and continues to provide a foundation for the state's floodplain management efforts, in conjunction with Executive Directive 2001-5 (see below).

EXECUTIVE ORDER 1998-5: A Michigan Executive Order issued by Governor John Engler on July 29, 1998 that established the Michigan Hazard Mitigation Coordinating Council (MHMCC) and assigned administrative functions associated with the council to the Emergency Management and Homeland Security Division, Department of State Police. (Note: Executive Order 2007-18 rescinded Executive Order 1998-5 and abolished the Michigan Hazard Mitigation Coordinating Council. See next definition below.)

EXECUTIVE ORDER 2007-18: A Michigan Executive Order issued by Governor Jennifer Granholm on May 2, 2007 that established the Michigan Citizen-Community Emergency Response Coordinating Council (MCCERCC) and assigned administrative functions associated with the council to the Emergency Management and Homeland Security Division, Department of State Police. The Michigan Citizen-Community Emergency Response Coordinating Council replaces the Michigan Citizen Corps Council, the Michigan Emergency Planning and Community Right-to-Know Commission, and the Michigan Hazard Mitigation Coordinating Council. The MCCERCC is responsible for developing and implementing emergency response and hazard mitigation plans for the state. The council also acts as the state emergency response commission as required by federal statute. (Note: Executive Order 2007-18 rescinded Executive Order 1998-5 and abolished the Michigan Hazard Mitigation Coordinating Council.)

EXECUTIVE DIRECTIVE 2001-5: A Michigan Executive Directive issued by Governor John Engler on September 11, 2001 that directed the Michigan Department of Environmental Quality, as the lead state agency, and the Michigan Hazard Mitigation Coordinating Council and various other state agencies to develop a statewide, interagency flood mitigation strategy to assure compliance with the State Flood Hazard Mitigation Plan (see Executive Order 1977-4 above). (Note: the Michigan Citizen-Community Emergency Response Coordinating Council has replaced the Michigan Hazard Mitigation Coordinating Council, per Executive Order 2007-18. See definition above.)

EXECUTIVE ORDERS 11988 AND 11990: The requirements to avoid direct or indirect support of floodplain development and to minimize harm to floodplains and wetlands. Federal decision-makers are obligated to comply with these orders, accomplished through an eight-step decision-making process.

EXECUTIVE ORDER 12699: Requires that new construction of Federal buildings must comply with appropriate seismic design and construction standards.

EXECUTIVE ORDER 12898: Requires Federal agencies to make environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations in the United States.

FACILITY: Any publicly or privately owned building, works, system, or equipment, built or manufactured, or an improved and maintained natural feature. Land used for agricultural purposes is not a facility.

FEDERAL COORDINATING OFFICER (FCO): The person appointed by the President to manage the federal response to a major disaster or emergency, including the provision of hazard mitigation assistance to a state.

FEDERAL EMERGENCY MANAGEMENT AGENCY (FEMA): The federal agency that coordinates emergency planning, preparedness, mitigation, response and recovery within the federal government. FEMA has been delegated primary responsibility for administering the President's Disaster Relief Program, which includes the Hazard Mitigation Grant Program (HMGP). FEMA also administers the Flood Mitigation Assistance Program (FMAP), Pre-Disaster Mitigation Program (PDMP), Repetitive Flood Claims Program (RFCP), and Severe Repetitive Loss Program (SRLP).

FEDERAL HAZARD MITIGATION OFFICER (FHMO): The FEMA employee responsible for representing the agency for each declaration in carrying out the overall responsibilities for hazard mitigation, including coordinating post-disaster hazard mitigation actions with other agencies of government at all levels.

FEDERAL-STATE AGREEMENT: The document that states the understandings, commitments, and conditions for assistance under which FEMA disaster assistance shall be provided. This agreement imposes binding obligations on FEMA, the State, and local governments in the form of conditions for assistance which are legally enforceable.

FINDING OF NO SIGNIFICANT IMPACT: A determination that an action will have no significant impact on the environment.

FLOOD MITIGATION ASSISTANCE PROGRAM (FMAP): A grant program created under the National Flood Insurance Reform Act of 1994 to provide mitigation planning and project grants to states and communities. The

program is funded through flood insurance policy fees. A maximum of $20 million in grant money is available annually.

FLOODPLAIN: The lowland and relatively flat areas adjoining inland or coastal waters including, at a minimum, that area subject to a one percent or greater chance of flooding in any given year (the "base flood" or "100-year flood).

FLOODPLAIN MANAGEMENT: An overall community program of corrective and preventive measures for reducing flood damage. These measures take a variety of forms and generally include zoning, subdivision or building requirements, or special purpose flood ordinances.

GRANT: An award of financial assistance.

GRANTEE: The government to which a grant is awarded and which is accountable for the use of the funds provided. The State of Michigan is the grantee for the Hazard Mitigation Grant Program (HMGP), Flood Mitigation Assistance Program (FMAP), Pre-Disaster Mitigation Program (PDMP), Repetitive Flood Claims Program (RFCP), and Severe Repetitive Loss Program (SRLP).

HAZARD MITIGATION: Any action taken to reduce or permanently eliminate the long-term risk to human life and property from natural, technological and human-related hazards.

HAZARD MITIGATION ASSISTANCE (HMA): An "umbrella" program that contains numerous sources of grant funds for hazard mitigation activities. Hazard Mitigation includes the following programs, which are themselves further described elsewhere in this plan (please refer to the subsection entitled "Funding Sources for Implementation of Mitigation Projects," found within the "Mitigation Strategy" section of this plan.)

HAZARD MITIGATION GRANT PROGRAM (HMGP): A grant program authorized under Section 404 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act that provides funding for hazard mitigation projects that are cost-effective and complement existing post-disaster mitigation programs and activities by providing funding for beneficial mitigation measures that are not funded through other programs.

HAZARD MITIGATION STATE ADMINISTRATIVE PLAN: The plan developed by the State to describe the procedures for administration of the Hazard Mitigation Grant Program and Flood Mitigation Assistance Program. These State Administrative Plans are separate, stand-alone support plans to the Michigan Hazard Mitigation Plan.

HAZARD MITIGATION STRATEGY: The report developed by the State, FEMA, other federal agencies, and affected local governments that identifies mitigation measures for implementation and recommends issues to be addressed in the State Hazard Mitigation Plan, including those measures recommended for funding under the Hazard Mitigation Grant Program (HMGP), Flood Mitigation Assistance Program (FMAP), Pre-Disaster Mitigation Program (PDMP), Repetitive Flood Claims Program (RFCP), Severe Repetitive Loss Program (SRLP), and other applicable programs. Hazard Mitigation Strategies developed for each Presidentially-declared disaster become addenda to the Michigan Hazard Mitigation Plan.

INTERAGENCY HAZARD MITIGATION TEAM (IHMT): The mitigation team that is activated following flood-related disasters pursuant to the Office of Management and Budget directive on Nonstructural Flood Protection Measures and Flood Disaster Recovery, and the subsequent December 15, 1980 Interagency Agreement for Nonstructural Damage Reduction.

LOCAL EMERGENCY MANAGEMENT COORDINATOR: The person appointed pursuant to 1976 PA 390, as amended, to coordinate emergency management activities for a county or municipal emergency management program. Also commonly called County or Local "Emergency Manager."

LOCAL GOVERNMENT:

a. Any county, city, village, town, district, regional authority, public college or university, or other political subdivision of any state, any Indian Tribe or authorized tribal organization, or Alaskan native village or organization; and

b. Any rural community or unincorporated town or village or any other public entity for which an application for assistance is made by a state or political subdivision.

MAJOR DISASTER: Any natural catastrophe (including any hurricane, tornado, storm, highwater, winddriven water, tidal wave, tsunami, earthquake, volcanic eruption, landslide, mudslide, snowstorm, or drought), or, regardless of cause, any flood, fire, or explosion, in any part of the United States which in the determination of the President cause damage of sufficient severity and magnitude to warrant major disaster assistance under the Stafford Act to supplement the efforts and available resources of states, local governments, and disaster relief organizations in alleviating the damage, loss, hardship, or suffering caused thereby.

MICHIGAN EMERGENCY MANAGEMENT PLAN (MEMP): The plan developed and continuously maintained by the Emergency Management and Homeland Security Division, Department of State Police, pursuant to 1976 PA

390, as amended, for the purpose of coordinating the emergency management activities of mitigation, preparedness, response and recovery within the state.

MICHIGAN CITIZEN-COMMUNITY EMERGENCY RESPONSE COORDINATING COUNCIL (MCCERCC): The body established on May 2, 2007 by Executive Order 2007-18 to replace the Michigan Hazard Mitigation Coordinating Council (see definition below), the Michigan Citizen Corps Council, and the Michigan Emergency Planning and Community Right-to-Know Commission. The MCCERCC is responsible for developing and implementing emergency response and hazard mitigation plans for the state. The council also acts as the state emergency response commission as required by federal statute. Executive Order 2007-18 assigned administrative functions associated with the MCCERCC to the Emergency Management and Homeland Security Division, Department of State Police.

MICHIGAN HAZARD MITIGATION COORDINATING COUNCIL (MHMCC): The body established by Executive Order 1998-5 and composed of representatives from key state agencies, local units of government, the planning industry, and the property and casualty insurance industry, which is responsible for evaluating hazards, identifying and developing strategies, coordinating resources, and implementing measures that will reduce the risk and vulnerability of people and property in Michigan from natural, technological and human-related hazards. (Note: Executive Order 2007-18 rescinded Executive Order 1998-5 and abolished the Michigan Hazard Mitigation Coordinating Council. See definition above.)

MICHIGAN HAZARD MITIGATION PLAN (MHMP): The plan developed and continuously maintained by the Emergency Management and Homeland Security Division, Department of State Police, which describes and coordinates the hazard mitigation activities of state agencies designed to reduce or eliminate the effects of disasters and emergency situations on Michigan citizens and communities.

MITIGATION MEASURE: Any mitigation project, activity, initiative or action proposed to reduce risk of future damage, hardship, loss, or suffering from disasters.

NATIONAL ENVIRONMENTAL POLICY ACT (NEPA): Public Law 91-190, as amended, which requires that actions affecting the environment comply with specific policies and procedures. NEPA requires that environmental information be available to public officials and citizens before decisions are made and actions are taken.

NATIONAL FLOOD INSURANCE PROGRAM (NFIP): The program established in 1968 under the National Flood Insurance Act to provide property owners in floodplains with federally-subsidized flood insurance in those communities that implement ordinances to reduce future flood losses. The National Flood Insurance Reform Act of 1994 revised and strengthened many aspects of the program.

PRELIMINARY DAMAGE ASSESSMENT (PDA): An assessment conducted by teams of federal, state and local officials to determine the severity and magnitude of a disaster and also to identify capabilities and resources of state, local and other federal agencies. Identification of hazard mitigation opportunities is a key part of the PDA process.

PRE-DISASTER MITIGATION PROGRAM (PDMP): The program authorized under Section 203 of the Stafford Act the provides funding to states and local communities for cost-effective hazard mitigation activities that complement a comprehensive mitigation program and reduce injuries, loss of life, and damage and destruction of property.

PROJECT: All mitigation work performed at a single site or multiple sites as described on a project summary.

PUBLIC ASSISTANCE: Federal financial assistance provided through the Public Assistance Grant Program (PAGP) to state and local governments or to eligible private nonprofit organizations for disaster-related requirements. Cost-effective hazard mitigation measures may be funded under the PAGP as part of public facility repair, restoration or reconstruction project.

RECORD OF ENVIRONMENTAL REVIEW: A document that is prepared for all Hazard Mitigation Grant Program (HMGP), Flood Mitigation Assistance Program (FMAP), Pre-Disaster Mitigation Program (PDMP), Repetitive Flood Claims Program (RFCP), and Severe Repetitive Loss Program (SRLP) projects to detail that potential environmental concerns will be addressed. This document serves to determine if an Environmental Assessment is needed.

REPETITIVE FLOOD CLAIMS PROGRAM (RFCP): A grant program authorized by the Bunning-Berauter-Blumenauer Flood Insurance Reform Act of 2004 that provides funding to reduce or eliminate the long-term risk of flood damage to structures insured under the National Flood Insurance Program (NFIP) that have had one or more claim payments for flood damages. The long-term goal of RFCP is to reduce or eliminate claims under the NFIP through mitigation activities that are in the best interest of the National Flood Insurance Fund (NFIF). RFCP funds may only mitigate structures that are located within a State or community that can not meet the cost share or management capacity requirements of the Flood Mitigation Assistance Program (FMAP).

SECTION 404: The section of the Stafford Act that authorizes the Hazard Mitigation Grant Program (HMGP). The HMGP provides funding for cost-effective hazard mitigation measures.

SECTION 406: The section of the Stafford Act that authorizes the Public Assistance Grant Program (PAGP). This program provides grants to repair, restore, or replace damaged facilities belonging to public and private non-profit entities, and other associated expenses, including emergency protective measures and debris removal. Cost-effective hazard mitigation measures are eligible for funding under the PAGP.

SEVERE REPETITIVE LOSS PROGRAM (SRLP): A grant program authorized by the Bunning-Bereuter-Blumenauer Flood Insurance Reform Act of 2004 that provides funding to reduce or eliminate the long-term risk of flood damage to severe repetitive loss residential structures insured under the National Flood Insurance Program (NFIP). The definition of severe repetitive loss as applied to this program was established in section 1361A of the National Flood Insurance Act, as amended (NFIA), 42 U.S.C. 4102a. An SRL property is defined as a **residential property** that is covered under an NFIP flood insurance policy and:

a. That has at least four NFIP claim payments (including building and contents) over $5,000 each, and the cumulative amount of such claims payments exceeds $20,000; or

b. For which at least two separate claims payments (building payments only) have been made with the cumulative amount of the building portion of such claims exceeding the market value of the building.

For both (a) and (b) above, at least two of the referenced claims must have occurred within any ten-year period, and must be greater than 10 days apart.

STAFFORD ACT: The Robert T. Stafford Disaster Relief and Emergency Assistance Act, PL 100-707, signed into law November 23, 1988. The Stafford Act amended the Disaster Relief Act of 1974, PL 93-288. The Stafford Act was amended by the Disaster Mitigation Act (DMA) of 2000 (PL 106-390), signed into law on October 30, 2000.

STANDARDS: Codes, specifications or standards for the construction of facilities to include legal requirements for additional features.

STATE COORDINATING OFFICER (SCO): The person appointed by the Governor to manage all aspects of a federally-declared disaster, in cooperation with the Federal Coordinating Officer (FCO). The Division Commander or Assistant Division Commander of the Emergency Management and Homeland Security Division, Department of State Police is normally appointed to this position.

STATE HAZARD MITIGATION OFFICER (SHMO): The person appointed by the State Coordinating Officer to serve as the primary point of contact with FEMA, other federal and state agencies, and local units of government in the planning and implementation of pre- and post-disaster mitigation activities (including management of the Hazard Mitigation Grant Program, Flood Mitigation Assistance Program, Pre-Disaster Mitigation Program, Repetitive Flood Claims Program, and Severe Repetitive Loss Program).

STATE INDIVIDUAL ASSISTANCE OFFICER (SIAO): The person appointed by the State Coordinating Officer to serve as the primary point of contact with FEMA, other federal and state agencies, and private, voluntary agencies and organizations in the provision of disaster relief assistance to individuals and families.

STATE PUBLIC ASSISTANCE OFFICER (SPAO): The person appointed by the State Coordinating Officer to manage the Public Assistance Grant Program on behalf of the State.

STATUTORY ADMINISTRATIVE COSTS: Under the Stafford Act, administrative costs for the preparation of applications for mitigation assistance, progress reports, audits, etc., are reimbursable based on a percentage of financial assistance received.

SUBGRANT: An award of financial assistance under a grant by a grantee to an eligible subgrantee.

SUBGRANTEE: The government or other legal entity to which a subgrant is awarded and which is accountable to the grantee for the use of the funds provided.

WET FLOODPROOFING: Permanent or contingent measures applied to a structure and/or its contents that automatically prevent or provide resistance to damage from flooding by intentionally allowing water to enter the structure. (Examples: Move all electrical outlets above expected flood levels; install floodwalls and protection closets around equipment [i.e., furnace, water heater] that cannot be relocated.)

WETLANDS: Those areas which are inundated or saturated by surface or ground water with a frequency sufficient to support, or that under normal hydrologic conditions does or would support, a prevalence of vegetation or aquatic life typically adapted for life in saturated or seasonally saturated soil conditions.

Introduction to the Hazard Analysis

This hazard analysis section has been completely updated from the previous 2011 edition of the Michigan Hazard Mitigation Plan. The advancements made in the 2012 Michigan Hazard Analysis have been incorporated in this updated 2014 document and supplemented with additional new material. This section provides a comprehensive update of all the material that had previously appeared in the Michigan Hazard Analysis, but it also includes additional detail about —one on Catastrophic Incidents (National Emergencies) and another on Celestial Impacts. The Catastrophic Incidents section has been added, in part, to better tie in with similar concepts being addressed in the Michigan Emergency Management Plan, and other documents and recommendations at the federal level. These changes make the plan not only compliant with FEMA planning standards, but with larger EMAP standards as well, with a full consideration of natural hazards, technological hazards, human-related hazards, as well as greater linkages between hazard mitigation and the other phases of emergency management—preparedness, response, and recovery.

In order to make such a large array of hazards more comprehensible, they have now been reorganized so that the most closely-related hazards are located near each other in the same section of this plan (instead of the alphabetical arrangement that had been used previously). There is extensive overlap between natural hazards. Similarly, technological hazards and human-related hazards tend to share a great deal in common with each other. Therefore, the hazard analysis component of this plan now includes three major divisions that correspond to these three major hazard classifications. Each of these three major sections has been further organized so that readers and responders can more easily find information about hazards that are closely related to each other. Persons who need information about weather hazards, for example, do not need to switch between sections separated by hundreds of pages, but instead can refer specifically to a single section of this plan.

This reorganized hazard analysis begins with a section on **natural hazards**. It makes sense to list these hazards first, because they so commonly affect Michigan. There is not a single part of Michigan that isn't susceptible to severe weather, for example. Within the natural hazards section, weather hazards have been listed first. Most of the weather hazards subsection deals with violent weather events such as thunderstorms and tornadoes, but there is also an entire component that addresses hazardous winter weather. One of the weather-related hazards, extreme temperatures, addresses both summer and winter weather issues in one section.

Many weather hazards affect the hydrological conditions in Michigan and its local communities, and therefore the weather hazards section is immediately followed by a section dealing with hydrological hazards—flooding and drought. The flood hazard section includes three major components—inland (riverine) flooding, Great Lakes shoreline hazards, and dam failures. The shoreline hazards component not only includes information about flooding, but other topics relevant to coastline areas along the Great Lakes—storm surges (seiches), rip currents, Great Lakes water recession, and shoreline erosion.

The first two natural hazard subsections flow well into a consideration of Michigan's two main ecological hazards—wildfires and invasive species. Both weather and hydrological conditions affect Michigan's ecological conditions, and its vulnerability to wildfires and invasive species. The natural hazards section wraps up with a subsection on Michigan's geological hazards. Although these are not insignificant, they tend not to pose as much direct risk to Michigan as the other types of natural hazards. This plan now includes a section titled "Celestial Impact," which considers such issues as solar storms that have the potential to disrupt important infrastructure, and the impact or threatened impact of physical bodies upon the Earth's land, sea, or atmosphere, the latter of which is rare as a hazard but has the potential for impacts that are truly catastrophic. These issues are here treated for the first time in State-level planning, and are given a realistic assessment (which can offset some of the alarmist media presentations that have appeared in recent years).

The **technological hazards** section includes two major subsections—one dealing with industrial hazards and the other with infrastructure problems. Within the industrial hazards subsection are components dealing with fires, hazardous materials incidents of various kinds, nuclear power plant issues, and accidents involving Michigan's oil and gas pipelines and wells. Within the subsection on infrastructure problems are components dealing with various forms of infrastructure failure, energy emergencies, and major transportation accidents.

The final major section of the hazard analysis, **human-related hazards**, contains five components, including a new consideration of the general topic of catastrophic incidents (national emergencies). In the past decade, major national incidents involving terrorism and hurricanes have made it clearer than ever how interconnected we all must be. We as a state experience both direct and indirect effects from events that take place elsewhere in the nation and the world. This new component of the hazard analysis provides an overview of events, such as 9/11 and Hurricanes Katrina and Rita, whose scale may necessitate extensive activities within Michigan even though the direct impacts of the event primarily occurred outside of our state. The section on civil disturbances has been extensively rewritten, to add additional information from social science research. Similarly, the section on nuclear attack has also been rewritten, to better reflect the new post-Cold War era in which the role of terrorist nuclear threats is of even greater concern. This is followed by an updated section on public health emergencies, which includes new information about the threat of pandemics, and the final section on terrorism has, like the nuclear attack section, been almost entirely rewritten, to better reflect the current geopolitical situation, as well as advances in our understanding of the threat, as informed by recent events and new research in homeland security studies.

The result of these changes is meant to be a document that is much more comprehensive, up-to-date, and valid than has appeared in any previous state plans, while also being easier to use. It is worth noting that many of the sources used in previous documents that provided an informational background for this plan were not always cited in a manner that allowed them to remain clearly connected with the material in this updated plan as that material was adapted for use here. Although this information was all reviewed and, in many cases, double-checked, the sources cited in this plan tend to only be ones used for the new material that was added to this plan. Citations for text adapted from earlier documents (e.g. the 2006 edition of the Michigan Hazard Analysis) might be tracked down through those earlier documents, but many government documents have differed over the years from academic documents, in the precision and consistency of citation use. Due to the large number of events described in lists throughout this document, the decision was made not to provide citations for every item. Some of the sources used are not ones that allow verification by most readers (such as LEIN messages, Flash Reports, local hazard mitigation plans, internal MSP documentation from disasters, and emergency management correspondence). If there is a question about any of the information in this document, inquiries can be directed to Mike Sobocinski at (517) 336-2053 (or sobocinskim@michigan.gov) and the information can then be double-checked or its basis explained. Amidst some internal discussion, there have been some references to the Wikipedia online encyclopedia included—not as a final information source, but to give it credit as providing a handy gateway to identifying numerous articles and internet sources whose validity was then judged and then considered for use as an authoritative source. For example, many of the Wikipedia entries led to articles that had originally appeared in peer-reviewed scientific journals.

One final note may also be helpful regarding the sometimes lengthy lists of historical incidents included in this plan. Some of the rarer types of incidents may use examples from outside of Michigan, when it was felt that an insufficient number or variety of Michigan examples was available, or because they involved scenarios that in some manner were deemed to be noteworthy for an analysis of that hazard. On the other hand, lengthy lists of Michigan examples have been provided for other hazards—often with a reduced font size. These lists sometimes contain specific local information, and are intended to help provide links between this state level plan and plans at the local level. The inclusion of some specific local information can be helpful in the development and update of local hazard mitigation plans, just as the review and consideration of local plans has been helpful for this update of the latest State plan. Readers may scrutinize or skim over those sections as they like, but this plan has been revised from the perspective that the best means of analyzing hazards is to maintain a solid historical grounding.

With an introductory overview now provided to readers, an outline of the full hazard analysis section is hereby presented, as a quick guide to the hundreds of pages that follow:

I. Natural Hazards
- A. Weather Hazards
  - 1. Storms
    - a. Thunderstorms, including hail and lightning
    - b. Winter storms, including ice, sleet, and snow
  - 2. Severe winds
  - 3. Tornadoes
  - 4. Extreme temperatures
  - 5. Fog
- B. Hydrological Hazards
  - 1. Flooding
    - a. Riverine flooding
    - b. Great Lakes shoreline hazards
    - c. Dam failures
  - 2. Drought
- C. Ecological Hazards
  - 1. Wildfires
  - 2. Invasive species
- D. Geological Hazards
  - 1. Ground Movement
    - a. Earthquakes
    - b. Subsidence
  - 2. Celestial Impacts

II. Technological Hazards
- A. Industrial Hazards
  - 1. Fires
    - a. Structural fires
    - b. Scrap tire fires
  - 2. Hazardous Materials Incidents
    - a. Hazardous materials incidents – fixed site (including industrial accidents)
    - b. Nuclear power plant emergencies
    - c. Hazardous materials incidents – transportation
    - d. Petroleum and natural gas pipeline accidents
    - c. Oil and natural gas well accidents
- B. Infrastructure Problems
  - 1. Infrastructure failures
  - 2. Energy emergencies
  - 3. Transportation accidents (air, rail, highway, marine)

III. Human-Related Hazards
- A. Catastrophic incidents (national emergencies)
- B. Civil disturbances
- C. Nuclear attack
- D. Public health emergencies
- E. Terrorism and similar criminal activities (including cyber-attacks)

Information about these hazards is summarized in the following table. Note that some entries in this table are based upon a limited analysis and therefore should be treated merely as rough estimates.

Hazard Analysis Summary Table

	Average annual events	Average annual deaths	Average annual injuries	Average annual property damage	Development trend effects	Risk rating: casualties	Risk rating: property	Risk Rating: economic costs	Risk rating: Infrastructure effects	Risk rating: Environment	Frequency as a top local hazard
Hail	**200**	**0.0**	**0.3**	**$16.6 million**	**+**	**0**	**2**	**2**	**1**	**1**	**Some**
Lightning	**16**	**0.8**	**5.8**	**$1.0 million**	**=**	**1**	**1**	**2**	**2**	**2**	**Some**
Ice and sleet storms	**17**	**0.1**	**0.3**	**$11.0 million**	**+**	**1**	**2**	**3**	**3**	**1**	**Some**
Snowstorms	**351**	**0.1**	**0.6**	**$2.3 million**	**+**	**1**	**1**	**2**	**2**	**1**	**Many**
Severe winds	**411**	**1.9**	**14.6**	**$25.4 million**	**+**	**1**	**2**	**3**	**3**	**1**	**Many**
Tornadoes	**16**	**3.0**	**33.0**	**$19.6 million**	**+**	**2**	**2**	**3**	**3**	**2**	**Many**
Extreme heat	**13**	**0.4**	**49.5**	**None reported**	**=**	**2**	**0**	**2**	**2**	**0**	**Some**
Extreme cold	**18**	**1.2**	**11.2**	**$0.3 million**	**=**	**2**	**2**	**3**	**3**	**1**	**Some**
Fog	**5**	**0.6**	**0.6**	**None reported**	**+**	**1**	**0**	**1**	**1**	**0**	**None**
Flooding	**52**	**0.5**	**0.4**	**$25.7 million**	**+**	**1**	**2**	**3**	**3**	**2**	**Some**
Shoreline hazards	**2**	**1.6**	**0.5**	**< $0.1 million**	**+**	**1**	**2**	**3**	**2**	**1**	**Some**
Dam failures	**> 1**	**> 0.1**	**> 0.1**	**$0.3 million**	**+**	**2**	**2**	**3**	**2**	**2**	**Some**
Drought	**3**	**0**	**0**	**$8.4 million**	**?**	**0**	**0**	**3**	**1**	**2**	**Few**
Wildfires	**> 1**	**0**	**0.2**	**$1.1 million**	**+**	**2**	**2**	**3**	**2**	**3**	**Some**
Invasive species	**< 1**	**< 1**	**> 1**	**> $1.0 million**	**?**	**1**	**2**	**3**	**1**	**3**	**None**
Earthquakes	**< 1**	**0**	**0**	**< $0.1 million**	**+**	**1**	**1**	**2**	**2**	**2**	**Few**
Subsidence	**> 1**	**< 0.1**	**< 1**	**$0.2 million**	**+**	**1**	**1**	**1**	**1**	**1**	**Few**
Celestial impacts (impacting object)	**< 1**	**0**	**0**	**< $0.1 million**	**+**	**0**	**1**	**1**	**1**	**1**	**None**
Celestial impacts (space weather)	**< 1**	**0**	**0**	**< $1.0 million**	**+**	**0**	**1**	**2**	**2**	**0**	**None**
Structural fires (major)	**> 1**	**> 1**	**> 1**	**> $1.0 million**	**-**	**2**	**2**	**2**	**1**	**2**	**Few**
Scrap tire fires	**< 1**	**0**	**0**	**< $1.0 million**	**=**	**0**	**1**	**2**	**1**	**2**	**Few**
Hazardous materials incident (fixed site)	**> 1**	**> 1**	**> 7**	**$57.0 million**	**+**	**2**	**2**	**2**	**2**	**2**	**Some**
Nuclear power plant	**< 1**	**0**	**0**	**< $0.1 million**	**+**	**0**	**1**	**2**	**2**	**2**	**Few**
Hazardous materials (transportation)	**> 1**	**> 1**	**> 1**	**> $3.0 million**	**+**	**2**	**2**	**2**	**2**	**2**	**Some**
Oil & gas pipelines	**> 1**	**> 1**	**> 1**	**$57.0 million**	**+**	**1**	**2**	**2**	**2**	**2**	**Few**
Oil & gas wells	**< 1**	**< 1**	**< 1**	**< $1.0 million**	**+**	**1**	**1**	**1**	**1**	**1**	**Few**
Infrastructure failures	**> 1**	**< 1**	**< 1**	**> $1.0 million**	**+**	**1**	**1**	**3**	**3**	**2**	**Some**
Energy emergencies	**< 1**	**0**	**0**	**None reported**	**+**	**0**	**0**	**2**	**2**	**1**	**None**
Transportation accidents (major)	**> 1**	**> 3**	**> 18**	**> $1.0 million**	**+**	**2**	**1**	**2**	**1**	**1**	**Few**
Catastrophic incidents	**< 1**	**0**	**0**	**Outside of MI**	**=**	**1**	**0**	**2**	**2**	**2**	**None**
Civil disturbances	**< 1**	**< 1**	**> 1**	**< $1.0 million**	**=**	**2**	**2**	**2**	**1**	**1**	**Few**
Nuclear attack	**< 1**	**> 1**	**> 1**	**> $1.0 million**	**-**	**2**	**2**	**2**	**2**	**2**	**Many**
Public health emergencies	**< 1**	**> 10**	**> 100**	**None reported**	**-**	**2**	**0**	**2**	**2**	**1**	**Few**
Terrorism and similar activities	**< 1**	**> 1**	**> 1**	**> $1.0 million**	**=**	**2**	**2**	**2**	**2**	**2**	**Some**

"**Average annual**" numbers are medium-term estimates only. Medium-term means that most estimates were based upon decades' worth of data, to predict future decades' risk. Some entries merely say less than (<) or greater than (>) some value.

Development trend effects use the following symbols to estimate the effects from Michigan's recent land use trends (which still mainly involve the construction of suburban, exurban, and rural detached homes for persons moving out of denser areas).
"+" means increasing risks, "=" means few net effects, "-" means decreasing risks, "?"means trends are unclear

Risk Ratings are based upon the estimated severity of average annual impacts (medium-term), as follows:
"0" means negligible: The risks as currently known are not likely to cause any emergency-level event.
"1" means minor: There is a known although infrequent chance for impacts of moderate or purely local severity.
"2" means significant: A regular pattern of moderate effects, or an infrequent chance of severe impacts.
"3" means major: A regular pattern or high risk of major impacts, of statewide significance.

"**Frequency as a top local hazard**" refers to the number of local plans listing this as one of their top hazards. Categories include "Many," "Some," "Few," and "None." Note that because FEMA requires the analysis of natural hazards, but not technological and human-related hazards, local plans are inclined to favor the listing of natural hazards.

I. Natural Hazards
A. Weather Hazards

The following outline summarizes the significant weather hazards covered in this section:

1. Storms
    a. Thunderstorms, including hail and lightning
    b. Winter storms, including ice, sleet, snow
2. Severe Winds
3. Tornadoes
4. Extreme Temperatures
5. Fog

These weather hazards can be thought of in general terms, according to whether they involve winter weather conditions or not. The winter storms section, and half of the extreme temperatures section, should be referred to for a good overview of Michigan's winter weather hazards. The other sections focus upon weather conditions that predominate in the non-winter months. However, it must be admitted that fog and strong winds may be present during the winter season as well, (although the strongest winds in Michigan usually occur during transition periods between warm and cool weather, and in association with severe thunderstorms). Strong winter winds may occur in conjunction with sleet and ice, and are a specific part of blizzard events, all described in the winter weather section. When ice and sleet have already weakened an area's tree limbs, power lines, and infrastructure, winter winds are often the final straw that causes tree limbs (or entire trees) to topple across roads or utility lines, causing life-threatening infrastructure breakdowns during periods of extreme cold. A big part of why this updated analysis now addresses all weather hazards within a single section is because there may not always be neat and precise distinctions between the different events. It makes sense to study these related topics together and then consider areas of overlap and similarity. But the most essential aspects of Michigan's winter weather hazards are described in the two sections: winter storms and extreme temperatures.

The non-winter months usually see the other types of severe weather hazards—thunderstorms and tornadoes, lightning and hail, and extreme heat. Thus, most of this section of the hazard analysis describes hazards that regularly occur during the non-winter months. The seasons in Michigan do not completely match those seen on the standard calendar, and they vary a little bit depending upon the area of the State being considered. As will be described further in the material on each hazard, Michigan's weather is affected by its location in the middle of the Great Lakes. Locations next to, or distant from, a Great Lakes shoreline, will often have different weather patterns and hazard risks. There is also a general trend relating to how far to the north the area under consideration is located. Michigan may be thought of in terms of three broad geographic divisions: the Upper Peninsula, the Northern Lower Peninsula, and the Southern Lower Peninsula. The Upper Peninsula, in addition to containing the northernmost locations and the areas of highest elevation (e.g Mount Arvon in Baraga County, at 603m), also has areas that are more exposed to weather patterns blowing in from the west, without the extent of moderating Lake Michigan influence enjoyed by the Lower Peninsula. This exposes the Upper Peninsula to colder average temperatures and longer winters. The Lower Peninsula contains a northern region that contains large areas of woodland, as well as areas of hilly landscape and higher elevation (e.g. Grove Hill, in northern Osceola County, at 522m) than its southern region, in which agricultural and urban land uses are predominant.

Although three general Michigan regions each have different degrees of risk and vulnerability from weather hazards, it is important to note that <u>all</u> of them are at-risk from each of the hazards in this section. The risks merely vary by the probability of the worst impacts, and the degree and severity of the "typical" impact. Every one of Michigan's 83 counties has experienced severe thunderstorms and at least one confirmed tornado. Every county is also susceptible to strong winds, extreme temperatures, and severe winter weather. The variation across Michigan is primarily one of likelihood and the range of intensity.

Therefore, for the weather hazards, it may make sense to think in terms of two parts of the year: winter and non-winter. Although mild snowfall and cold temperatures may occur a little bit outside of the main period of wintry weather, such events tend not to be serious ones, and therefore a general distinction can be made between the "winter weather risk season" and the "non-winter weather risk season." The winter weather risk season is defined in terms of historically documented events involving extreme cold and significant snowstorms. Seasons of winter weather risk include months during which record low temperatures are near enough to zero to make it likely that wind chill advisories would be issued, and when record snowfall levels have amounted to several inches. Even if these events are less likely on the "edges" of the season, since they have occurred, it made sense to define risk periods in terms of these possibilities. On the flip side, all the other months are susceptible to extreme heat (months in which record high temperatures go above 90 degrees Fahrenheit and thus make it likely that a heat advisory might need to be issued.

On the basis of this historical analysis, it was determined that the risk periods for extreme temperature and snowfall events can be assigned to the following months, for Michigan's three general regions. (NOTE: Do <u>not</u> use these seasons to define severe wind risks. For example, strong tornadoes have occurred in months such as October and April.)

1. Southern Lower Peninsula:	Winter risk season from late November to early April Non-winter risk season from early May to late September

(extend that last risk season to early October for the southernmost tiers of counties, such as Berrien and Wayne)

2. Northern Lower Peninsula:	Winter risk season from early November to April Non-winter risk season from late May to late September
3. Upper Peninsula	Winter risk season from Late September to May Non-winter risk season from late May to early September

Some variation may be expected between counties, especially shoreline counties that observe the tempering effect of the Great Lakes, but these may be good "rules of thumb" for the times of the year when different types of weather risks will occur in different parts of Michigan. The extreme heat hazard, for example, will affect the Upper Peninsula for a somewhat shorter time period each year than it does the Southern Lower Peninsula. However, this difference does not change the fact that once the risk season has arrived, both areas are at risk. In July, for example the City of Ironwood has recorded a record high temperature of 103 degrees, and although the record high temperatures in the Southern Lower Peninsula have reached 108 degrees, the all-time highest recorded temperature in Michigan actually came from the Northern Lower Peninsula, when Oscoda County hit 112 degrees (although the major weather stations at other locations across the region report records of 106 degrees). Thus, although there are differences and trends between regions and within them, the fact that <u>all</u> have experienced extreme heat waves must be recognized. In other words, the commonalities shared by Michigan's regions are more important than the differences, when it comes to weather-hazard preparedness and mitigation.

Historic Precipitation and Snowfall Records at Various Michigan Locations

Southern Lower Peninsula	Record Precipitation	Record Snowfall
Adrian (Lenawee County)	4.74” (Sept. 3)	15.0” (Jan. 26)
Benton Harbor (Berrien County)	6.60” (May 30)	25.0” (Dec. 6)
Coldwater (Branch County)	5.37” (June 26)	17.0” (Jan. 26)
Ann Arbor (Washtenaw County)	4.54” (Aug. 6)	15.8” (Dec.1)
Bloomingdale (Van Buren Co.)	9.78” (Sept. 1)	20.0” (Dec. 10)
Detroit (Wayne County)	4.74” (July 31)	24.5” (April 6)
Jackson (Jackson County)	5.31” (June 21)	16.0” (March 17)
Pontiac (Oakland County)	4.75” (Oct. 1)	18.0” (Dec. 2)
Flint (Genesee County)	6.04” (Sept. 10)	14.5” (Jan. 26)
Grand Rapids (Kent County)	4.22” (June 5 & Aug. 19)	16.1” (Jan. 26)
Port Huron (St. Clair County)	3.97” (Sept. 7)	14.3” (March 27)
Harbor Beach (Huron County)	6.04” (Sept. 10)	18.0” (Feb. 21)
Big Rapids (Mecosta County)	7.64” (Sept. 11)	16.0” (Jan. 30)

The counties listed above start with the southernmost tier in Michigan, and proceed generally northward, tier by tier.

Northern Lower Peninsula	Record Precipitation	Record Snowfall
Alpena (Alpena County)	5.14” (Sept. 3)	18.2” (Feb. 22)
East Tawas (Iosco County)	3.72” (Aug. 16)	20.0” (Feb. 14)
Gaylord (Otsego County)	5.00” (Aug. 17)	20.0” (Nov. 23)
Gladwin (Gladwin County)	5.00” (May 20)	15.0” (Dec. 11)
Traverse City	4.30” (Aug. 23)	16.0” (Jan. 25 & Nov. 29)
Upper Peninsula	**Record Precipitation**	**Record Snowfall**
Hancock (Houghton County)	3.58” (May 17 & Sept. 4)	26.5” (Jan. 18)
Ironwood (Gogebic County)	6.72” (July 21)	24.0” (Dec. 16)
Munising (Alger County)	3.51” (May 31)	20.0” (March 15)
Sault Ste. Marie (Chippewa Co.)	5.92” (Aug. 3)	26.6” (Dec. 10)

Source: Extreme Michigan Weather, by Paul Gross (2010, University of Michigan Press, Ann Arbor)

For more information about the assessment of rainfall events (which can cause flash flooding), please refer to the precipitation-related information contained in the Thunderstorm Hazards section.

NOTE: In addition to numerous sources already referenced* in previous editions of this plan, the update and newly added text for this 2014 Michigan Hazard Mitigation Plan has benefited greatly from the following printed books:

Michigan Geography and Geology, edited by Randall Schaetzl, Joe Darden, and Danita Brandt. Pearson Custom Publishing, New York, et al., 2009.

Natural Disasters and How We Cope, chief consultant Robert Coenraads. Millenium House, Elanora Heights Australia, 2006. Used to expand information in numerous hazard analysis sections.

Secrets & Lies: Digital Security in a Networked World, by Bruce Schneier. Wiley Publishing, Inc. paperback edition: 2000, 2004. Used to expand the cyber-security information.

Additional sources from government documents, news articles, and internet sites will be provided later in this document.

* Note: A huge array of newspaper articles, web sites, government documents, official records, and books of all types have formed the basis of the information in this document. However, since previous editions did not connect each source with its corresponding text, there has not been a clear way to amend this document’s bibliography to correspond with the extensive changes that have been made over the years. Some sources used in earlier documents are expected to be out of date, and some of them were never listed when the 2006 update of the Michigan Hazard Analysis was published. Therefore, although the authors are confident in the quality of the information here, much of this edition does not attempt specific citations.

Overlap Between Weather Hazards and Other Sections of the Hazard Analysis

Extreme summer heat can increase the chances of wildfires (which has its own chapter in the "Ecological Hazards" section of this plan). Weather events involving precipitation have effects upon local hydrology. Heavy precipitation, and/or melting snow, can cause flooding. Ice jams and log jams (a source of which may include woody debris toppled into drains and streams by strong winds) can also cause flooding. For more information about flooding, please refer to the sections on Riverine and Shoreline flooding in the next section of this hazard analysis, dealing with "Hydrological Hazards." Also in the hydrological section is a chapter on droughts, which also have their origin in weather, but stem from experiencing too little precipitation rather than too much.

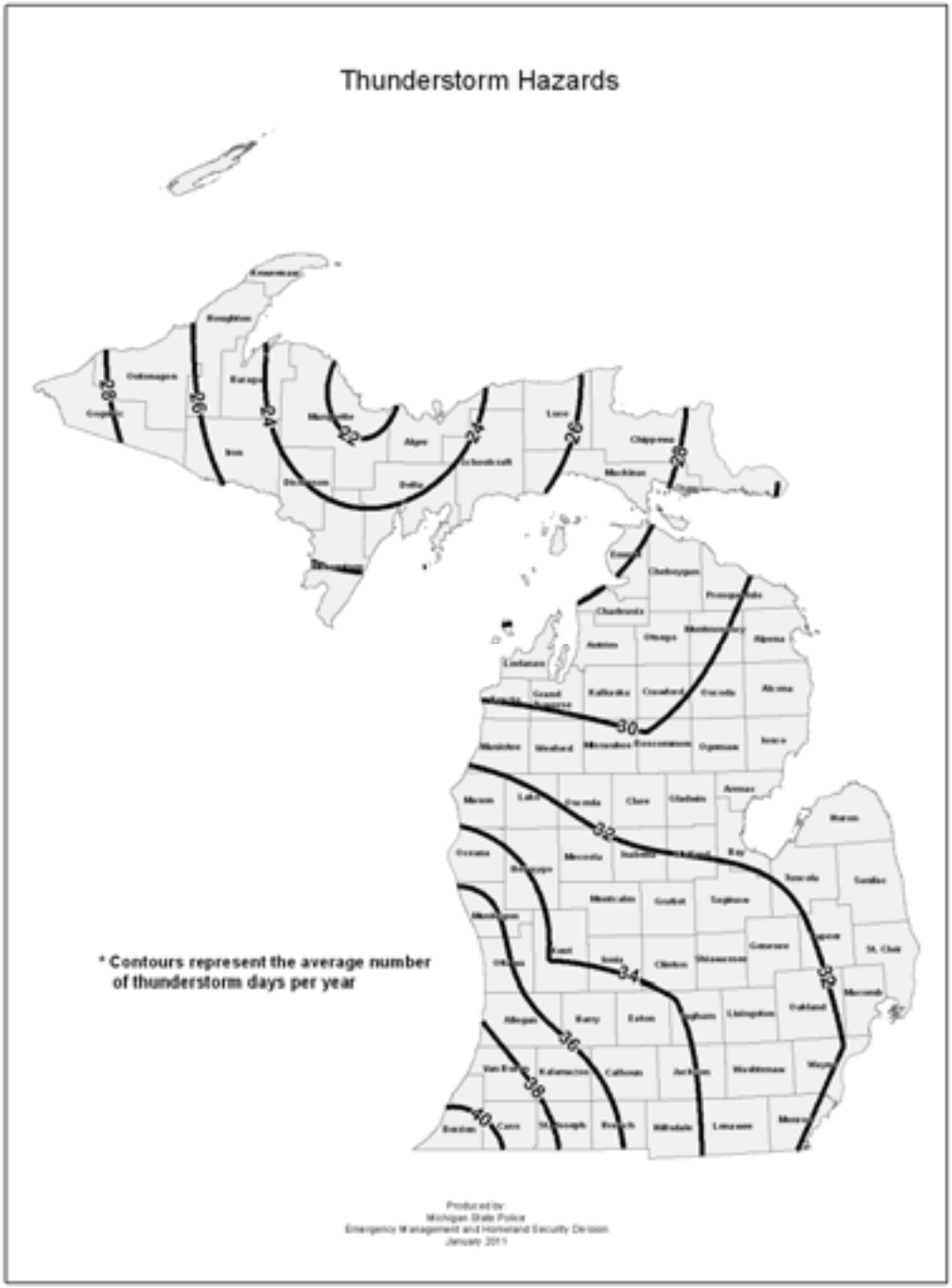
There is a strong connection between all of these extreme weather events and the "technological hazard" of infrastructure failure, which has its own chapter in the "Technological Hazards" section of this plan. Severe weather has also been a factor in major transportation accidents, which also has a chapter of its own in the Technological Hazards section.

Revised Treatment of Hazard Mitigation Strategies in this Edition of the MHMP

Previous MSP/EMHSD documents have tended to consider a wide array of activities that could in some manner help to protect lives, property, the environment, etc., without clearly distinguishing which of these activities are hazard mitigation and which ones deal with other phases of emergency management (preparedness, response, or recovery). This plan update will emphasize, where possible, the types of activities that are most properly considered to be hazard mitigation, especially those that are (or should be) eligible for federal funding. The reason for this change is because of a large number of local hazard mitigation plans that predominantly identify preparedness activities rather than hazard mitigation. It must be admitted that not all of the hazards faced by Michigan are ones that have very clear-cut hazard mitigation activities, although many preparedness, response, and recovery activities have already been identified in the previous edition of this plan. **Input is requested from all readers to help identify effective hazard mitigation activities for inclusion in this (as well as future and local-level) hazard mitigation document(s).**

Thunderstorm Hazards

Severe thunderstorms are weather systems accompanied by strong winds (at least 56mph), lightning, heavy rain (that could cause flash flooding), hail (at least ¾" diameter), or tornadoes. Severe thunderstorms can occur at any time in Michigan, although they are most frequent during the warm spring and summer months from May through September. The potential thunderstorm threat is often measured by the number of "thunderstorm days" – defined as days in which thunderstorms are observed. As the map below indicates, various areas in Michigan are subject to an average of at least 20 thunderstorm days per year, and up to just over 40 days per year in the state's southwestern corner. The Lower Peninsula, in general, is subject to approximately 28-40 thunderstorm days per year, while the Upper Peninsula average is closer to 20-30 thunderstorm days per year. This map is based upon new weather service data from various weather stations within (and near) Michigan.



Thunderstorms form when a shallow layer of warm, moist air is overrun by a deeper layer of cool, dry air. Cumulonimbus clouds, frequently called "thunderheads," are formed in these conditions. These clouds are often enormous (up to six miles or more across and 40,000 to 50,000 feet high) and may contain tremendous amounts of water and energy. That energy is often released in the form of high winds, excessive rains, lightning, and possibly hail and tornadoes.

Thunderstorms are typically short-lived (often lasting no more than 30-40 minutes) and fast moving (30-50 miles per hour). Strong frontal systems, however, may spawn one squall line after another, composed of many individual thunderstorm cells. Severe thunderstorms may also cause severe flood problems because of the torrential rains that they may bring to an area. Thunderstorms sometimes move very slowly, and can thus dump a tremendous amount of precipitation onto a location. Flooding can result, including flash floods, "urban flooding," and riverine flooding. Please refer to the hydrological hazard section for more information about these hazards. Large complexes of thunderstorms, called mesoscale convection systems (MCS), may operate as a larger-scale weather system and persist for several hours or more.

The following sections address in greater detail these specific thunderstorm hazards: 1) hail; 2) lightning; 3) severe winds; and 4) tornadoes (although most of these hazards can also occur when no thunderstorm activity is evident).

One positive aspect of assessing thunderstorm risks comes from the fact that thunderstorm hazards have some degree of predictability and are closely monitored by the National Weather Service. In addition to daily forecasts, which predict the probability of rainy or stormy weather, the NWS system of Watches and Warnings helps communities understand when there is a potential risk of severe thunderstorms, or if severe thunderstorms are imminent. When the NWS issues a "Severe Thunderstorm Watch," it means that thunderstorms with large hail and damaging winds are possible in your area. When the NWS issues a "Severe Thunderstorm Warning," it signifies that severe thunderstorms (with the damaging winds and hail) are in your area or are imminent.

The NWS has five offices that serve Michigan and are responsible for monitoring and providing predictions and bulletins for the entire state. The five offices are in Grand Rapids, Detroit, Gaylord, Marquette, and North Webster (Indiana). These stations provide information on severe weather watches and warnings, but also provide useful Doppler Radar images that track the movement of thunderstorms in your area. The North Webster office covers portions of southwest Michigan (www.weather.gov/iwx); the Grand Rapids station covers the remainder of southwest Michigan (www.weather.gov/grr); the Detroit station covers Southeast Michigan (www.weather.gov/dtx); the Gaylord station covers the north central portion of the Lower Peninsula and the eastern edge of the Upper Peninsula (www.weather.gov/apx); and the Marquette station examines the majority of the Upper Peninsula (www.weather.gov/mqt).

Since thunderstorms bring the potential for dangerous hail, lightning, straight-line winds, and tornadoes, it is necessary to further examine each of those hazards in the other sections of this plan. **Useful historical information on hail, severe winds, lightning, and tornadoes for your county can be found through the National Climatic Data Center's Storm Data website at** http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwEvent~Storms. Data for each county in the state are listed there, and there are historical records of significant events for dozens of hazards. This is one of the most convenient information sources for the analysis of hazards, and was used extensively in this plan.

Hazard Mitigation Strategies for General Thunderstorm Hazards

- Increased coverage and use of NOAA Weather Radio.
- Public early warning systems and networks.
- Tree trimming and maintenance to prevent limb breakage and safeguard nearby utility lines. (Ideal: Establishment of a community forestry program with a main goal of creating and maintaining a disaster-resistant landscape in public rights-of-way.)
- Buried/protected power and utility lines (where appropriate).

Emphasis in Local Hazard Mitigation Plans

Thunderstorms were identified as one of the most significant hazard in local hazard mitigation plans for the following counties: Allegan, Antrim, Arenac, Calhoun, Cass, Clare, Delta, Emmet, Genesee, Grand Traverse, Gratiot, Huron,

Ionia, Isabella, Kalamazoo, Kalkaska, Leelanau, Luce, Mackinac, Marquette, Missaukee, Ogemaw, Osceola, Roscommon, Saginaw, Shiawassee, Tuscola, Washtenaw, and Wayne.

Michigan's 10 climate divisions (for the monitoring and analysis of precipitation)

Source: Rainfall Frequency Atlas of the Midwest, by Floyd A Huff and James R. Angel. Midwestern Climate Center and Illinois State Water Survey, 1992

Instructions for the Use of This Section

This section is useful for the assessment of rain and thunderstorm events, with implications also for flash flooding. It allows various levels of rainfall precipitation events to be interpreted in terms of their severity, based upon the historical frequency with which such events had occurred in the past.

The map at left shows Michigan's ten climate divisions, each of which is matched with data in the multi-page table below. (See page 136 for a list of counties located within each division.) The table contains sections listing numbers for each of Michigan's ten divisions. For a given precipitation event, find the row that most closely matches the duration of the rainfall event. Move across the row to find the number that is closest to the number of inches of rainfall for that event. The column in which that number appears tells the "recurrence interval" for that level of precipitation. A recurrence interval is the average amount of time that elapses between precipitation events of that particular severity level. Longer recurrence intervals indicate a more severe event. The most extreme events listed in the table are those with a 100-year recurrence interval. Such events are so severe that they are expected (on average) to occur only about one time per century. Precipitation-based flooding is more likely to result from events with a longer recurrence interval. Any Michigan rainfall amounts that exceed the values listed in the table are very rare and severe indeed!

As an example of the procedure described above, if an Ingham County event had caused 3 inches of rain to fall during a 6-hour period, the Division 9 section of the table contains a row labeled "6-hr" and the column that most closely matches the 3" rainfall amount contains a value of 3.07", matching up with a 25-year recurrence interval (definitely a major rainfall event).

Table: Mean Frequency Distributions for Storm Periods of 5 Minutes to 10 Days, by Climate Division, and Recurrence Intervals of 2 Months to 100 Years in Michigan (for use with thunderstorm and flood hazards)

		Rainfall (inches) for each given recurrence interval											
Division	*Duration*	*2-month*	*3-month*	*4-month*	*6-month*	*9-month*	*1-year*	*2-year*	*5-year*	*10-year*	*25-year*	*50-year*	*100-year*
01	10-day	1.69	2.04	2.35	2.76	3.17	3.45	4.28	5.34	6.17	7.27	8.11	8.99
01	5-day	1.41	1.69	1.91	2.22	2.55	2.77	3.38	4.23	4.91	5.86	6.65	7.50
01	72-hr	1.24	1.46	1.65	1.91	2.20	2.39	2.96	3.69	4.29	5.11	5.79	6.49
01	48-hr	1.14	1.33	1.48	1.72	1.98	2.15	2.64	3.31	3.84	4.59	5.20	5.86
01	24-hr	1.07	1.25	1.37	1.58	1.79	1.95	2.39	3.00	3.48	4.17	4.73	5.32
01	18-hr	1.01	1.17	1.28	1.48	1.68	1.83	2.25	2.82	3.27	3.92	4.45	5.00
01	12-hr	0.94	1.09	1.19	1.38	1.56	1.70	2.08	2.61	3.03	3.63	4.12	4.63
01	6-hr	0.80	0.93	1.02	1.18	1.34	1.46	1.79	2.25	2.61	3.13	3.55	3.99
01	3-hr	0.69	0.80	0.88	1.01	1.15	1.25	1.53	1.92	2.23	2.67	3.03	3.40
01	2-hr	0.62	0.72	0.79	0.92	1.04	1.13	1.39	1.74	2.02	2.42	2.74	3.09
01	1-hr	0.51	0.59	0.64	0.75	0.85	0.92	1.12	1.41	1.64	1.96	2.22	2.50
01	30-min	0.40	0.46	0.50	0.58	0.66	0.72	0.88	1.11	1.29	1.54	1.75	1.97
01	15-min	0.29	0.34	0.37	0.43	0.49	0.53	0.65	0.81	0.94	1.13	1.28	1.44
01	10-min	0.23	0.26	0.29	0.33	0.38	0.41	0.50	0.63	0.73	0.88	0.99	1.12
01	5-min	0.13	0.15	0.16	0.19	0.21	0.23	0.29	0.36	0.42	0.50	0.57	0.64
02	10-day	1.61	1.94	2.23	2.62	3.02	3.28	3.93	4.78	5.44	6.43	7.22	7.98
02	5-day	1.25	1.50	1.70	1.97	2.26	2.46	3.00	3.71	4.25	5.11	5.81	6.55
02	72-hr	1.15	1.35	1.52	1.77	2.03	2.21	2.62	3.27	3.78	4.57	5.23	5.94
02	48-hr	0.97	1.13	1.26	1.46	1.68	1.83	2.31	2.98	3.49	4.24	4.88	5.55
02	24-hr	0.91	1.06	1.16	1.34	1.53	1.66	2.09	2.71	3.19	3.87	4.44	5.03
02	18-hr	0.86	1.00	1.09	1.26	1.44	1.56	1.96	2.55	3.00	3.64	4.17	4.73
02	12-hr	0.79	0.92	1.01	1.17	1.32	1.44	1.82	2.36	2.78	3.37	3.86	4.38
02	6-hr	0.69	0.80	0.88	1.01	1.15	1.25	1.57	2.03	2.39	2.90	3.33	3.77
02	3-hr	0.58	0.68	0.74	0.86	0.98	1.06	1.34	1.73	2.04	2.48	2.84	3.22
02	2-hr	0.53	0.61	0.67	0.78	0.88	0.96	1.21	1.57	1.85	2.24	2.58	2.92
02	1-hr	0.43	0.50	0.55	0.63	0.72	0.78	0.98	1.27	1.50	1.82	2.09	2.36
02	30-min	0.34	0.39	0.43	0.49	0.56	0.61	0.77	1.00	1.18	1.43	1.64	1.86
02	15-min	0.25	0.29	0.31	0.36	0.41	0.45	0.56	0.73	0.86	1.04	1.20	1.36
02	10-min	0.19	0.22	0.24	0.28	0.32	0.35	0.44	0.57	0.67	0.81	0.93	1.06
02	5-min	0.11	0.13	0.14	0.16	0.18	0.20	0.25	0.33	0.38	0.46	0.53	0.60

Page 2 of Table: Mean Frequency Distributions for Storm Periods of 5 Minutes to 10 Days, by Climate Division, and Recurrence Intervals of 2 Months to 100 Years in Michigan (for use with thunderstorm and flood hazards)

		Rainfall (inches) for each given recurrence interval											
Division	*Duration*	*2-month*	*3-month*	*4-month*	*6-month*	*9-month*	*1-year*	*2-year*	*5-year*	*10-year*	*25-year*	*50-year*	*100-year*
03	10-day	1.63	1.96	2.26	2.66	3.06	3.33	3.99	4.92	5.65	6.66	7.50	8.35
03	5-day	1.29	1.54	1.75	2.02	2.33	2.53	3.10	3.91	4.57	5.46	6.23	7.04
03	72-hr	1.09	1.27	1.44	1.67	1.92	2.09	2.62	3.36	3.96	4.86	5.56	6.35
03	48-hr	0.97	1.13	1.26	1.46	1.68	1.83	2.34	3.02	3.55	4.31	4.94	5.60
03	24-hr	0.89	1.04	1.13	1.31	1.49	1.62	2.09	2.70	3.21	3.89	4.47	5.08
03	18-hr	0.84	0.97	1.06	1.23	1.40	1.52	1.96	2.54	3.02	3.66	4.20	4.78
03	12-hr	0.78	0.90	0.99	1.14	1.30	1.41	1.82	2.35	2.79	3.38	3.89	4.42
03	6-hr	0.67	0.78	0.85	0.99	1.12	1.22	1.57	2.03	2.41	2.92	3.35	3.81
03	3-hr	0.57	0.67	0.73	0.84	0.96	1.04	1.34	1.73	2.05	2.49	2.86	3.25
03	2-hr	0.52	0.60	0.66	0.76	0.86	0.94	1.21	1.57	1.86	2.26	2.59	2.95
03	1-hr	0.42	0.49	0.53	0.62	0.70	0.76	0.98	1.27	1.51	1.83	2.10	2.39
03	30-min	0.33	0.38	0.42	0.49	0.55	0.60	0.77	1.00	1.19	1.44	1.65	1.88
03	15-min	0.24	0.28	0.31	0.36	0.40	0.44	0.56	0.73	0.87	1.05	1.21	1.37
03	10-min	0.19	0.22	0.24	0.28	0.31	0.34	0.44	0.57	0.67	0.82	0.94	1.07
03	5-min	0.10	0.12	0.13	0.15	0.17	0.19	0.25	0.32	0.39	0.47	0.54	0.61
04	10-day	1.56	1.88	2.17	2.55	2.93	3.19	3.77	4.56	5.22	6.10	6.85	7.60
04	5-day	1.26	1.51	1.70	1.98	2.27	2.47	2.99	3.68	4.23	4.97	5.58	6.23
04	72-hr	1.12	1.31	1.48	1.72	1.98	2.15	2.63	3.27	3.75	4.45	5.00	5.60
04	48-hr	1.00	1.17	1.30	1.51	1.74	1.89	2.32	2.88	3.33	3.93	4.43	4.95
04	24-hr	0.94	1.09	1.20	1.39	1.57	1.71	2.11	2.62	3.04	3.60	4.06	4.53
04	18-hr	0.89	1.03	1.13	1.30	1.48	1.61	1.98	2.46	2.86	3.38	3.82	4.26
04	12-hr	0.82	0.95	1.04	1.21	1.37	1.49	1.84	2.28	2.64	3.13	3.53	3.94
04	6-hr	0.70	0.82	0.90	1.04	1.18	1.28	1.58	1.96	2.28	2.70	3.05	3.40
04	3-hr	0.60	0.70	0.76	0.88	1.00	1.09	1.35	1.68	1.95	2.30	2.60	2.90
04	2-hr	0.54	0.63	0.69	0.80	0.91	0.99	1.22	1.52	1.76	2.09	2.35	2.63
04	1-hr	0.44	0.51	0.56	0.65	0.74	0.80	0.99	1.23	1.43	1.69	1.91	2.13
04	30-min	0.35	0.40	0.44	0.51	0.58	0.63	0.78	0.97	1.12	1.33	1.50	1.68
04	15-min	0.25	0.29	0.32	0.37	0.42	0.46	0.57	0.71	0.82	0.97	1.10	1.22
04	10-min	0.20	0.23	0.25	0.29	0.33	0.36	0.44	0.55	0.64	0.76	0.85	0.95
04	5-min	0.12	0.13	0.15	0.17	0.19	0.21	0.25	0.31	0.36	0.43	0.49	0.54
05	10-day	1.64	1.97	2.27	2.67	3.07	3.34	4.14	5.28	6.21	7.59	8.75	10.02
05	5-day	1.38	1.65	1.86	2.16	2.48	2.70	3.36	4.30	5.07	6.25	7.26	8.36
05	72-hr	1.18	1.38	1.56	1.81	2.08	2.26	2.88	3.74	4.46	5.45	6.31	7.26
05	48-hr	1.04	1.22	1.36	1.58	1.81	1.97	2.53	3.34	4.01	4.97	5.81	6.73
05	24-hr	0.97	1.13	1.24	1.43	1.63	1.77	2.28	3.00	3.60	4.48	5.24	6.07
05	18-hr	0.91	1.06	1.16	1.34	1.53	1.66	2.14	2.82	3.38	4.21	4.93	5.71
05	12-hr	0.85	0.99	1.08	1.25	1.42	1.54	1.98	2.61	3.13	3.90	4.56	5.28
05	6-hr	0.73	0.85	0.93	1.08	1.22	1.33	1.71	2.25	2.70	3.36	3.93	4.55
05	3-hr	0.62	0.72	0.79	0.92	1.04	1.13	1.46	1.92	2.30	2.87	3.35	3.88
05	2-hr	0.57	0.66	0.72	0.83	0.95	1.03	1.32	1.74	2.09	2.60	3.04	3.52
05	1-hr	0.46	0.53	0.58	0.67	0.76	0.83	1.07	1.41	1.69	2.11	2.46	2.85
05	30-min	0.36	0.42	0.45	0.53	0.60	0.65	0.84	1.11	1.33	1.66	1.94	2.25
05	15-min	0.26	0.31	0.34	0.39	0.44	0.48	0.62	0.81	0.97	1.21	1.41	1.64
05	10-min	0.20	0.24	0.26	0.30	0.34	0.37	0.48	0.63	0.76	0.94	1.10	1.27
05	5-min	0.12	0.13	0.15	0.17	0.19	0.21	0.27	0.36	0.43	0.54	0.63	0.73
06	10-day	1.76	2.12	2.44	2.87	3.30	3.59	4.31	5.36	6.21	7.46	8.51	9.54
06	5-day	1.44	1.72	1.95	2.26	2.59	2.82	3.40	4.22	4.89	6.11	7.17	8.31
06	72-hr	1.23	1.45	1.64	1.90	2.18	2.37	2.88	3.62	4.24	5.27	6.17	7.18
06	48-hr	1.09	1.28	1.42	1.65	1.90	2.06	2.51	3.17	3.71	4.59	5.35	6.20
06	24-hr	1.02	1.19	1.30	1.51	1.71	1.86	2.27	2.85	3.34	4.15	4.84	5.62
06	18-hr	0.96	1.12	1.23	1.42	1.61	1.75	2.13	2.68	3.14	3.90	4.55	5.28
06	12-hr	0.89	1.04	1.13	1.31	1.49	1.62	1.97	2.48	2.91	3.61	4.21	4.89
06	6-hr	0.76	0.89	0.97	1.13	1.28	1.39	1.70	2.14	2.50	3.11	3.63	4.22
06	3-hr	0.65	0.76	0.83	0.96	1.09	1.19	1.45	1.82	2.14	2.66	3.10	3.60
06	2-hr	0.59	0.69	0.76	0.87	0.99	1.08	1.32	1.65	1.94	2.41	2.81	3.26
06	1-hr	0.48	0.56	0.61	0.70	0.80	0.87	1.07	1.34	1.57	1.95	2.27	2.64
06	30-min	0.38	0.44	0.48	0.56	0.63	0.69	0.84	1.05	1.24	1.54	1.79	2.08
06	15-min	0.28	0.32	0.35	0.41	0.46	0.50	0.61	0.77	0.90	1.12	1.31	1.52
06	10-min	0.21	0.25	0.27	0.32	0.36	0.39	0.48	0.60	0.70	0.87	1.02	1.18
06	5-min	0.12	0.14	0.15	0.18	0.20	0.22	0.27	0.34	0.40	0.50	0.58	0.67

Page 3 of Table: Mean Frequency Distributions for Storm Periods of 5 Minutes to 10 Days, by Climate Division, and Recurrence Intervals of 2 Months to 100 Years in Michigan (for use with thunderstorm and flood hazards)

		Rainfall (inches) for given recurrence interval											
Division	*Duration*	*2-month*	*3-month*	*4-month*	*6-month*	*9-month*	*1-year*	*2-year*	*5-year*	*10-year*	*25-year*	*50-year*	*100-year*
07	10-day	1.57	1.89	2.18	2.56	2.94	3.20	3.88	4.75	5.39	6.21	6.83	7.48
07	5-day	1.22	1.46	1.66	1.92	2.21	2.40	2.96	3.68	4.23	4.99	5.61	6.26
07	72-hr	1.11	1.30	1.47	1.70	1.96	2.13	2.62	3.28	3.78	4.49	5.05	5.66
07	48-hr	1.02	1.20	1.33	1.54	1.78	1.93	2.37	2.97	3.41	4.03	4.52	5.04
07	24-hr	0.96	1.12	1.23	1.42	1.61	1.75	2.14	2.65	3.05	3.56	3.97	4.40
07	18-hr	0.90	1.05	1.15	1.33	1.51	1.64	2.01	2.49	2.87	3.35	3.73	4.14
07	12-hr	0.84	0.97	1.06	1.23	1.40	1.52	1.86	2.31	2.65	3.10	3.45	3.83
07	6-hr	0.72	0.84	0.92	1.06	1.21	1.31	1.61	1.99	2.29	2.67	2.98	3.30
07	3-hr	0.62	0.72	0.78	0.91	1.03	1.12	1.37	1.70	1.95	2.28	2.54	2.82
07	2-hr	0.56	0.65	0.71	0.82	0.93	1.01	1.24	1.54	1.77	2.06	2.30	2.55
07	1-hr	0.45	0.52	0.57	0.66	0.75	0.82	1.01	1.25	1.43	1.67	1.87	2.07
07	30-min	0.36	0.42	0.45	0.53	0.60	0.65	0.79	0.98	1.13	1.32	1.47	1.63
07	15-min	0.26	0.30	0.33	0.38	0.43	0.47	0.58	0.72	0.82	0.96	1.07	1.19
07	10-min	0.20	0.24	0.26	0.30	0.34	0.37	0.45	0.56	0.64	0.75	0.83	0.92
07	5-min	0.12	0.13	0.15	0.17	0.19	0.21	0.26	0.32	0.37	0.43	0.48	0.53
08	10-day	1.81	2.18	2.51	2.95	3.39	3.69	4.33	5.23	5.96	7.39	8.63	10.03
08	5-day	1.48	1.77	2.00	2.32	2.67	2.90	3.45	4.27	4.95	6.16	7.28	8.46
08	72-hr	1.29	1.52	1.72	1.99	2.29	2.49	3.00	3.75	4.41	5.50	6.45	7.51
08	48-hr	1.14	1.33	1.48	1.72	1.98	2.15	2.63	3.32	3.91	4.93	5.83	6.82
08	24-hr	1.07	1.25	1.37	1.58	1.79	1.95	2.37	3.00	3.52	4.45	5.27	6.15
08	18-hr	1.01	1.17	1.28	1.48	1.68	1.83	2.23	2.82	3.31	4.18	4.95	5.78
08	12-hr	0.94	1.09	1.19	1.38	1.56	1.70	2.06	2.61	3.06	3.87	4.58	5.35
08	6-hr	0.80	0.93	1.02	1.18	1.34	1.46	1.78	2.25	2.64	3.34	3.95	4.61
08	3-hr	0.69	0.80	0.88	1.01	1.15	1.25	1.52	1.92	2.25	2.85	3.37	3.94
08	2-hr	0.62	0.72	0.79	0.92	1.04	1.13	1.37	1.74	2.04	2.58	3.06	3.57
08	1-hr	0.51	0.59	0.64	0.75	0.85	0.92	1.11	1.41	1.65	2.09	2.48	2.89
08	30-min	0.40	0.46	0.50	0.58	0.66	0.72	0.88	1.11	1.30	1.65	1.95	2.28
08	15-min	0.29	0.34	0.37	0.43	0.49	0.53	0.64	0.81	0.95	1.20	1.42	1.66
08	10-min	0.23	0.26	0.29	0.33	0.38	0.41	0.50	0.63	0.74	0.93	1.11	1.29
08	5-min	0.13	0.15	0.16	0.19	0.21	0.23	0.28	0.36	0.42	0.53	0.63	0.74
09	10-day	1.77	2.13	2.45	2.89	3.32	3.61	4.26	5.15	5.83	6.81	7.60	8.40
09	5-day	1.43	1.71	1.93	2.24	2.58	2.80	3.36	4.10	4.71	5.57	6.27	6.99
09	72-hr	1.27	1.49	1.68	1.95	2.24	2.44	2.93	3.59	4.16	4.95	5.59	6.28
09	48-hr	1.17	1.37	1.52	1.77	2.03	2.21	2.66	3.28	3.79	4.50	5.10	5.73
09	24-hr	1.12	1.30	1.42	1.64	1.87	2.03	2.42	2.98	3.43	4.09	4.63	5.20
09	18-hr	1.05	1.22	1.34	1.55	1.76	1.91	2.27	2.80	3.22	3.84	4.35	4.89
09	12-hr	0.97	1.13	1.24	1.43	1.63	1.77	2.11	2.59	2.98	3.56	4.03	4.52
09	6-hr	0.84	0.97	1.06	1.23	1.40	1.52	1.82	2.24	2.57	3.07	3.47	3.90
09	3-hr	0.71	0.83	0.91	1.05	1.20	1.30	1.55	1.91	2.20	2.62	2.96	3.33
09	2-hr	0.65	0.76	0.83	0.96	1.09	1.18	1.40	1.73	1.99	2.37	2.69	3.02
09	1-hr	0.52	0.61	0.66	0.77	0.87	0.95	1.14	1.40	1.61	1.92	2.18	2.44
09	30-min	0.41	0.48	0.52	0.61	0.69	0.75	0.90	1.10	1.27	1.51	1.71	1.92
09	15-min	0.30	0.35	0.38	0.45	0.51	0.55	0.65	0.80	0.93	1.10	1.25	1.40
09	10-min	0.24	0.28	0.30	0.35	0.40	0.43	0.51	0.63	0.72	0.86	0.97	1.09
09	5-min	0.13	0.15	0.17	0.19	0.22	0.24	0.29	0.36	0.41	0.49	0.56	0.62
10	10-day	1.56	1.88	2.17	2.55	2.93	3.19	3.82	4.64	5.27	6.11	6.79	7.51
10	5-day	1.28	1.53	1.73	2.01	2.31	2.51	3.05	3.68	4.16	4.78	5.26	5.74
10	72-hr	1.18	1.38	1.56	1.81	2.08	2.26	2.74	3.34	3.76	4.31	4.74	5.16
10	48-hr	1.08	1.26	1.41	1.63	1.88	2.04	2.48	3.04	3.44	3.96	4.36	4.78
10	24-hr	1.03	1.20	1.31	1.51	1.72	1.87	2.26	2.75	3.13	3.60	3.98	4.36
10	18-hr	0.97	1.13	1.23	1.43	1.62	1.76	2.12	2.59	2.94	3.38	3.74	4.10
10	12-hr	0.90	1.04	1.14	1.32	1.50	1.63	1.97	2.39	2.72	3.13	3.46	3.79
10	6-hr	0.77	0.90	0.98	1.13	1.29	1.40	1.69	2.06	2.35	2.70	2.99	3.27
10	3-hr	0.66	0.77	0.84	0.97	1.10	1.20	1.45	1.76	2.00	2.30	2.55	2.79
10	2-hr	0.59	0.69	0.76	0.87	0.99	1.08	1.31	1.59	1.82	2.09	2.31	2.53
10	1-hr	0.48	0.56	0.62	0.71	0.81	0.88	1.06	1.29	1.47	1.69	1.87	2.05
10	30-min	0.38	0.44	0.48	0.56	0.63	0.69	0.84	1.02	1.16	1.33	1.47	1.61
10	15-min	0.28	0.32	0.35	0.41	0.46	0.50	0.61	0.74	0.85	0.97	1.07	1.18
10	10-min	0.21	0.25	0.27	0.32	0.36	0.39	0.47	0.58	0.66	0.76	0.84	0.92
10	5-min	0.12	0.14	0.15	0.18	0.20	0.22	0.27	0.33	0.38	0.43	0.48	0.52

Hail

Conditions where atmospheric water particles from thunderstorms form into rounded or irregular lumps of ice that fall to the earth.

Hazard Description

Hail is produced by thunderstorms when strong updrafts among the clouds carry water droplets above the freezing level and cause the formation of ice pellets around some nucleus (such as a water crystal or speck of dust). These can remain suspended in the winds and can continue to grow larger until their weight is no longer supportable and they fall to earth, possibly accompanied by heavy rains. Falling hailstones batter crops, dent autos, and injure wildlife and people. Large hail is a characteristic of severe thunderstorms, and it may precede the occurrence of a tornado.

Hail can be especially damaging to crops, home roofs, and automobiles. Approximately $1 billion in damages occurs annually across the United States. In Michigan, there is usually at least one intense hailstorm per year that causes significant damages. Unfortunately, for many hailstorms, the total damages to property go unreported.

As a product of the strong thunderstorms that frequently move across the state, the size of hail is usually proportional to the intensity of the storm cell that generates it. As a thunderstorm passes over, hail usually falls near the center of the storm, along with the heaviest rain. Sometimes, strong winds occurring at high altitudes in the thunderstorm can blow the hailstones away from the storm center, causing an unexpected hazard at places that otherwise might not appear threatened.

Hazard Analysis

Most hailstones reported in Michigan range in size from a pea (¼” diameter) to a golf ball (1¾” diameter), but hailstones larger than baseballs (2¾” diameter) have occurred with the most severe thunderstorms. In 2009, the official cut-point that denotes severe hail events was increased from 0.75” to 1.00”. The following table provides the official classifications of hail magnitude, as often used in weather reporting and event records. Some statistics cover multiple categories of hail magnitude (by combining table cells together).

Descriptive size of hail	Diameter	Number of MI events (1996-2013)	Impacts:	Areas of occurrence
Pea	¼” (6mm)	Too many to include	Common occurrence. Impacts not tallied—usually minimal.	Every county in Michigan
Marble or mothball	½” (13mm)			
Penny or dime	¾” (19mm)	} 2080	Old threshold for severe hail, raised to 1” in 2009.	Every county in Michigan
Nickel	0.9” (22mm)	}		
Quarter	1” (25mm)	} 1022	$70,028,000 property damage, $2.79M in crop damage	Every county in Michigan
Half-dollar	1¼” (32mm)	}		
Walnut or ping-pong ball	1½” (38mm)	} 427	$201.229M property damage, $3.025M crop damage, 3 inj.	Almost all counties across the state
Golf ball	1¾” (44mm)	}		
Hen’s egg	2” (51mm)	52	$7.33 million in property damage, $615,000 in crop damages, 1 injury	43 counties located across the entire state
Tennis ball	2½” (64mm)	8		
Baseball	2¾” (70mm)	14		
Tea cup	3” (76mm)	7	$6.031M in property damage	Worst in Western U.P.
Grapefruit	4” (102mm)	2	$800K in property damage	Gogebic, Jackson
Softball	4½” (114mm)	0		
	TOTAL:	3612	$288M property, $8M crop	All MI counties

Sources: Two left columns—Coenraads 2006:224, three right columns—NCDC Storm Events database.

The likelihood of severe hailstorms in specific Michigan counties is expected to be proportional to the frequency of thunderstorms in that county, but as the tables in this chapter show, the impacts of hail are much harder to characterize than the mere frequency of occurrence (of which the map of Michigan thunderstorm days in the preceding section might provide a general indication).

Hail History for Michigan Counties – arranged by region – Jan. 1996 to Oct. 2013
(The Lower Peninsula regions are ordered by "tiers" from south to north, west to east)
Please refer to the Michigan Profile Map section for an explanation of regional divisions

COUNTY or area	Hail Events	Days with Hail	Tot. property damage	Tot. crop damage	Injuries
Washtenaw	154	65	$10,000		
Wayne	146	63	$7,000		
.Livingston	45	27			
Oakland	147	67	$11,000		
Macomb	122	62	$2,000		
5 Co Metro region	123 avg.	57 avg.	Total $30,000	-	0
Berrien	39	24	$8,000	$1,300,000	
Cass	23	19	$12,000		
St. Joseph	41	25			
Branch	54	29	$1,000,000		
Hillsdale	35	23	$2,000,000		
Lenawee	91	49	$2,150,000		1
Monroe	74	42			
.Van Buren	26	22	$50,355,000	$230,000	
Kalamazoo	54	40	$129,680,000	$370,000	
Calhoun	34	14	$325,000	$285,000	
Jackson	37	33	$380,000	$225,000	
.Allegan	47	30	$652,000	$372,000	
Barry	39	32	$360,000	$205,000	
Eaton	41	33	$435,000	$325,000	
Ingham	40	26	$400,000	$235,000	
.Ottawa	53	39	$497,000	$297,000	
Kent	74	50	$14,952,000	$370,000	
Ionia	14	13	$4,175,000	$100,000	
Clinton	26	19	$150,000	$115,000	
Shiawassee	36	28	$2,800,000	$2,000,000	
Genesee	157	64			
Lapeer	59	34			
St. Clair	71	37	$125,000		
.Muskegon	40	26	$425,000	$250,000	
Montcalm	25	20	$1,145,000	$135,000	1
Gratiot	25	19	$145,000	$120,000	
Saginaw	86	38	$300		
Tuscola	65	44			
Sanilac	49	33	$155,000	$10,000	
.Mecosta	22	18	$315,000	$160,000	
Isabella	33	21	$145,000	$170,000	
Midland	72	38	$1,000		
Bay	41	27			2
Huron	54	37	$5,000		
34 Co S Lower Pen	49 avg.	31 avg.	Total $212,792,300	Total $7,274,000	4

Continued on next page…

Part 2 of Hail History for Michigan Counties – arranged by region

.Oceana	21	18	$200,000	$115,000	
Newaygo	28	21	$245,000	$150,000	
.Mason	16	12	$80,000	$25,000	
Lake	15	12	$110,000	$65,000	
Osceola	14	12	$75,000	$70,000	
Clare	29	25	$455,000	$110,000	
Gladwin	29	24			
Arenac	31	22			
.Manistee	19	12		$35,000	
Wexford	22	18			
Missaukee	14	13			
Roscommon	31	25			
Ogemaw	35	20			
Iosco	47	28			
.Benzie	9	8			
Grand Traverse	18	15			
Kalkaska	9	9			
Crawford	18	15			
Oscoda	34	20			
Alcona	41	28			
.Leelanau	29	19		$55,000	
Antrim	25	16		$30,000	
Otsego	36	18			
Montmorency	25	20			
Alpena	28	19			
.Charlevoix	26	19			
Emmet	15	12	$100,000		
Cheboygan	15	12			
Presque Isle	26	18	$3,500,000	$300,000	1
29 Co N Lower Pen	24 avg.	18 avg.	Total $4,765,000	Total $955,000	1
Gogebic	45	25	$750,000		
Iron	42	26	$4,100,000		
Ontonagon	45	31			
Houghton	43	24	$10,000		
Keweenaw	4	4			
Baraga	31	24			
.Marquette	114	50	$64,647,000		
Dickinson	54	35	$225,000		
Menominee	54	34	$100,000		
Delta	63	33	$4,000		
Schoolcraft	32	25	$100,000		
Alger	40	24	$5,000		
.Luce	15	14			
Mackinac	12	10			
Chippewa	22	15			
15 Co Upper Pen	41 avg.	25 avg.	Total $69,941,000	-	0
MICHIGAN TOTAL	3,612	584	$287,523,300	$8,229,000	5

Although damaging hail is much less frequent than thunderstorms, since only a fraction of all thunderstorms produce damaging hail, there is still an unusual aspect to the types of events that cause damages to occur. Hail is most likely for severe thunderstorms that also produce great amounts of precipitation, but although damaging hail has occurred in every part of Michigan, the events producing the largest-sized hail are not always reported to be damaging, and much

smaller-sized hail often causes far greater negative impacts. The vast majority of reported property damage in Michigan stems from just a few events. This unusual pattern is also reflected in the geographic variation in damage reports by county. As shown in the 2-page table on the previous pages, most of the property damage caused by hail in the past 18 years had been reported within just a few counties: Kalamazoo, Marquette, and Van Buren. The pattern seen in the data suggests a geographic component to damaging hail risks—since there is no clear reason why the Detroit Metro area would be more damage-resistant than the Kalamazoo or Grand Rapids areas, the severe hail damages in the latter areas would appear to either stem from pure chance or from geographic differences across Michigan. This geographic hypothesis suggests that there are two areas of strongest risk from damaging hail: those in the inland-southwestern areas of the Lower Peninsula, and the Iron-Marquette portion of the Central Upper Peninsula.

Alternatively, the geographic pattern of the worst recent hail events may just be an artifact of the relatively small number of severely damaging events. If so, then the severe hail hazard might be characterized in a manner similar to tornadoes, in that a severe event has the potential to cause severe damage to any location in Michigan, but that the chance of any specific location being struck is very rare. Therefore, for most of Michigan's citizens, hail will appear to be a mere curiosity that seems infrequent and harmless. This impression is held by far fewer persons who are responsible for agricultural produce. They are aware that hail can be extremely harmful to their crops. Many kinds of produce are vulnerable to damage, whether fruit or vegetable: potatoes, beans, tomatoes, corn, soybeans, apples, peaches, grapes, plums, cherries and raspberries have all been severely damaged by hailstorms in Michigan.

Property damage often involves hail impacts upon motor vehicles, but widespread damage to the roofs and siding of homes can also occur. Even though automobiles can be protected in garages, some hail is large enough to cause damage to built structures themselves. Thus, in addition to the other types of thunderstorm hazards (lightning, winds and tornadoes, and excessive precipitation), serious damage can come from severe hail.

A major damaging hail event can be expected in Michigan at least once every 2 to 3 years, although the typical county will see such impacts only over the course of several decades. The National Weather Service began recording hail activity in Michigan in 1967. Statistics since that time indicate that approximately 50% of the severe thunderstorms that produce hail have occurred during the months of June and July, and nearly 80% have occurred during the prime growing season of May through August. As a result, the damage to crops from hail can be extensive.

There have been 5 injuries in Michigan due to hail events since the beginning of 1996. These involved persons who were outdoors and directly exposed to the impact of hailstones. Two of the injuries occurred in a sailboat during a hailstorm in 1999. Another was a motorcyclist who received a minor injury when struck on the mouth. The other injury documented on NCDC involved a person who was attempting to move a vehicle into a shelter, and was thus exposed.

The National Weather Service forecasts of severe thunderstorms usually give sufficient warning time to allow residents to take appropriate action to reduce the effects of hail damage on vehicles and some property. However, it is very difficult to prevent damage to crops. More details about specific Michigan events, and resulting damages, is provided in the subsection, below, about significant Michigan hailstorms. At least $100 million in property and crop damage has occurred from hail events in Michigan since 1990.

Impact on the Public

Hail generally causes minor property damage within its area of impact, but large hail also discourages the public from outdoor activities and events, due to concerns involving safety and comfort.

Impact on Public Confidence in State Governance

If hail causes infrastructure failures, a question may be raised about the adequacy of that infrastructure, its maintenance, and its design and regulation. In events that require mass sheltering, such as schools or large gatherings (e.g. a county fair or community-sponsored event), the ability of local and state government to adequately plan for severe weather is often vital to the success of such events, which themselves are often important for various sectors of the local and state economy. Citizen discontent and media-exacerbated controversies have arisen from situations in which inadequate planning was evident, or provisions for public sheltering were inadequate.

Impact on Responders

Responders tend to be working outdoors in conditions from which most residents are taking shelter. Although special training and safety precautions have usually been taken (e.g. for line-repair workers), nevertheless, responders are more exposed to and at-risk from the impacts of hail. Fortunately, most episodes of hail are brief and it is usually easy to take cover to avoid being injured.

Impact on the Environment

Hail is a product of strong thunderstorms, usually occurs along with the heaviest rain, and ranges in size from a pea to a golf ball (and in some rare occurrences, a baseball). The primary effects on the natural environment include physical damage to vegetation such as forests, plants, and crops, and physical harm to wildlife species. Plants with well-established root systems will seldom die, but some younger or smaller forms of vegetation may not survive a severe hail storm. Hail can damage some fruit and vegetable plants and render them unsuitable for consumption by humans. This can also lead to an increased risk of bacteria that can kill healthy trees as well as nearby wildlife. The impact of hail can cause soil erosion that can exacerbate flooding, and large ice can potentially clog or reduce the effectiveness of drainage paths, culverts, and grates.

Significant Hailstorms in Michigan since 1985

May 1985 - Lower Peninsula (western and eastern counties)

In May 1985, severe thunderstorms accompanied by hail struck the western and eastern counties of the Lower Peninsula, causing great damage. Two-inch hail was reported in Cass County and $2 million in damages to fruit crops were reported in Kent County.

March 27, 1991 - Lower Peninsula (central and southern counties)

On March 27, 1991 severe thunderstorms and accompanying high winds and hail caused considerable damage across a large portion of central and southern Lower Michigan, damaging homes, businesses, farms and some public facilities. A total of three deaths and 27 injuries were attributed to the storms. Egg to baseball-sized hail, some exceeding 2.5” in diameter, was reported in the vicinity of Buchanan in Berrien County. In Kalamazoo and Portage in Kalamazoo County, softball size hail, up to 4.5” in diameter, did extensive damage to automobiles, windows and trees.

April 12, 1996 - Lower Peninsula (southern counties)

Up to golf ball sized hail fell across southern Michigan along the path of severe thunderstorms. Tree limbs, power lines, windows, aluminum and vinyl siding on houses were damaged. Numerous recreational vehicles parked at a dealership were badly damaged. The event resulted in $6 million in property damage throughout southern Michigan.

July 2, 1997 - Lower Peninsula (Berrien County)

A severe thunderstorm during the early morning hours of July 2, 1997 pounded Berrien County with 1” to 2.25” diameter hail that caused agricultural losses of nearly $1 million. The hail destroyed 280 acres of fruits and 100 acres of vegetables in a two-mile wide swath from Stevensville southeast to the county line. Damaging hail was reported in numerous other locations across the Lower Peninsula on July 2 – just one of the impacts of a storm system that would eventually spawn deadly tornadoes in southeast Michigan and lead to a Presidential Disaster Declaration. (Refer to the Tornadoes section for additional information.)

June 24, 1998 - Lower Peninsula (central and southern counties)

On June 24, 1998 two tracts of severe thunderstorms crossed the state moving east to west – one tract stretched across central Lower Michigan, while the other moved into the southern portion of the state. The more northerly thunderstorms produced large amounts of hail in several counties, ranging from dime to quarter sized hail up to baseball size (2.75” in diameter) hail. Damage was widespread, but not overly severe. However, in Petoskey, hail (2.5” in diameter) caused $100,000 in damage to cars on two lots west of town. In Ingham County, near Onondaga, baseball-sized hail damaged auto glass and roofs, but specific damage figures were not available.

Sept. 26, 1998 - Lower Peninsula (northern counties)

A line of severe thunderstorms that ravaged northern Lower Michigan during the weekend of September 26-27, 1998 produced hail up to 2” in diameter in Manistee County, destroying an estimated 30,000-35,000 bushels of apples at area farms. The same storm system produced tennis ball-sized hail north of the town of Gladwin, which damaged several homes and vehicles. In Arenac County, near Sterling, 3.5” diameter hail damaged crops and injured some livestock at area farms, and damaged several homes, satellite dishes, and vehicles.

June 9, 2000 - Iron River (Iron County); Randville-Grand Bluff (Dickinson County)

In the early morning hours of June 9, 2000 a line of thunderstorms moved through Iron County, producing 1.75” hail that damaged approximately 575 homes and 700 vehicles in a two-mile wide swath across the northern two-thirds of the city of Iron River. The hail caused approximately $2.3 million in roof and siding damage. Ping-pong ball sized hail in the Randville-Grand Bluff area in Dickinson County caused $225,000 in damage to 20 homes and 20 vehicles. Total hail damage in Iron and Dickinson Counties was $4.1 million.

July 14, 2000 - Algonac (St. Clair County)

On the afternoon of July 14, 2000 severe thunderstorms producing large hail struck St. Clair County. Hailstones as large as baseballs (2.75” in diameter) fell in Algonac, causing $125,000 in damage to cars and homes. The hailstones damaged roofs, ripped gutters off of homes, dented air conditioning units, and broke windows. The force of impact when the hailstones landed in the canals in Algonac caused the water to splash five feet into the air.

July 13, 2004 - Posen (Presque Isle County)

On July 13, 2004 a devastating hailstorm caused extensive damage in the small town of Posen in Presque Isle County. The hail (2.75” in diameter) was driven at times by wind gusts around 60 miles per hour. Most buildings and vehicles in the community suffered some sort of damage. Holes were punched in roofs and siding, cars were dented and windows were broken. A local church had to patch 300 holes in its roof. Damage to a school roof was estimated at nearly $200,000, and a local greenhouse lost over a thousand two-foot by two-foot window panes. One individual suffered a badly bruised back as he tried to move his vehicle to shelter. Substantial damage was done to crops (largely potatoes, along with some beans, tomatoes and corn) in nearby fields.

July 28, 2006 – Western Upper Peninsula (Gogebic County)

An approaching cold front interacting with an extremely unstable airmass triggered a widespread outbreak of severe weather across western and central Upper Michigan from the late afternoon on the 28th until just after sunrise on the 29th. Hail of up to 4 inches in diameter resulted in significant damage to roofs, siding, and automobiles. Damage estimates in Wakefield and surrounding areas had been reported as over $60 million, but hail damages are currently listed in the NCDC storm events database as specifically totaling $750,000 in Wakefield. 11 counties across the Central and Western Upper Peninsula were also affected.

June 20, 2007 – Marquette (Marquette County)

One of the most significant hailstorms in memory pummeled downtown Marquette and Harvey during the afternoon of June 20, 2007. While most of the hail was less than golf ball size, there were a few reports of hail that was three inches in diameter. The hail accumulated to several inches deep in downtown Marquette, and storm drains clogged from shredded leaves caused melting hail to result in street flooding. Hundreds of houses sustained significant damage to roofs and sidings. In addition, thousands of cars were damaged. Damage estimates from the storm for Marquette and surrounding areas were reported to total over $60 million.

July 26, 2007 – Southern Lower Peninsula (especially Shiawassee, Muskegon, Lenawee Counties)

Large hail hammered areas in a 3 mile radius around Durand for 50 minutes. The hail, at times, was as big as golf balls. A local newspaper reported $1.8 million in hail damages to homes alone. Hundreds of homes and vehicles were significantly damaged, with the latter averaging $4,000 per vehicle. This resulted in an estimate of $1 million in total vehicle damages. Many crops in the area were also destroyed. One farmer estimated $400,000 in losses to soybeans alone. Total crop damages were conservatively estimated at $2 million, bringing the total cost of the hailstorm to nearly $5 million. A local newspaper reported $75,000 in total damages to patrol cars and other vehicles at the Lenawee County Fair. This event will be remembered for the extreme intensity of large hail that it generated.

April 5, 2010 – Southwestern Michigan

Severe thunderstorms produced large hail and winds greater than 80 mph. The most significant damage occurred in the southern portions of Kalamazoo County, with damages estimated at $125 million, but Van Buren County was also struck heavily, with damages estimated at $50 million. To the west-southwest of Schoolcraft (Kalamazoo County), the siding of many homes was destroyed on the homes' western sides, where it was battered by large hail of about 1.75 inches in diameter. The estimated damages from this storm event include strong wind effects, not just hail impacts.

April 26, 2011 – Southern Lower Peninsula (especially Kent, Ionia, and Kalamazoo Counties)

Several thunderstorm supercells produced large hail reported as up to 2" in diameter. An EF-0 tornado near Burnips (Allegan County) and an injurious lightning strike in Portage (Kalamazoo County) also occurred during this weather event. Hail damages included areas northeast of Belding (Ionia County, $4 million), south of Stanton (Montcalm County, $1 million), across northern Kalamazoo County ($4 million), and in Kent County ($2 million).

Programs and Initiatives

Note: Many of the programs and initiatives in place to mitigate, prepare for, respond to, and recover from other severe thunderstorms hazards (straight-line winds, lightning and tornadoes) have the dual purpose of also protecting against hail. As a result, there is some overlap in the narrative programs and initiatives descriptions for each respective hazard. This redundancy allows each hazard section to stand alone, eliminating the need to refer to other hazard sections for basic information.

National Weather Service Doppler Radar

The National Weather Service (NWS) has completed a major modernization program designed to improve the quality and reliability of weather forecasting. The keystone of this improvement is Doppler Weather Surveillance Radar, which can more easily detect severe weather events that threaten life and property – including storms that are likely to produce damaging hail. Most important, the lead time and specificity of warnings for severe weather have improved significantly.

Doppler technology calculates both the speed and the direction of wind motion inside of severe storms. By providing data on the wind patterns within developing storms, the system allows forecasters to better identify the conditions leading to severe weather such as tornadoes, severe straight-line winds, lightning and damaging hail. This means early detection of the precursors to severe storms, as well as information on the direction and speed of storms once they form.

National Weather Service Watches/Warnings

The National Weather Service issues severe thunderstorm watches for areas when the meteorological conditions are conducive to the development of severe thunderstorms. People in the watch area are instructed to stay tuned to National Oceanic and Atmospheric Administration (NOAA) weather radio and local radio or television stations for weather updates, and watch for developing storms. Once radar or a trained Skywarn spotter detects the existence of a severe thunderstorm, the National Weather Service will issue a severe thunderstorm warning. The warning will identify where the storm is located, the direction in which it is moving, and the time frame during which the storm is expected to be in the area. Persons in the warning area are instructed to seek shelter immediately.

The State and local government agencies are warned via the Law Enforcement Information Network (LEIN), NOAA weather radio, and the Emergency Managers Weather Information Network (EMWIN). Public warning is provided through the Emergency Alert System (EAS). The National Weather Service stations in Michigan transmit information directly to radio and television stations, which in turn pass the warning on to the public. The National Weather Service also provides detailed warning information on the Internet at www.weather.gov, where an interactive map can be used.

Severe Weather Awareness Week

Each spring, the Emergency Management and Homeland Security Division of the Department of State Police, in conjunction with the Michigan Committee for Severe Weather Awareness, sponsors Severe Weather Awareness Week.

This annual public information and education campaign focuses on such severe weather events as tornadoes, thunderstorms, lightning, high winds, flooding and hail. Informational materials on hail and other thunderstorm hazards are disseminated to schools, hospitals, nursing homes, other interested community groups and facilities, and the general public.

Hazard Mitigation Activities for Hail

- Increased coverage and use of NOAA Weather Radio.
- Public early warning systems and networks.
- Tree trimming and maintenance to prevent limb breakage and to safeguard nearby utility lines. (Ideal: Establishment of a community forestry program with a main goal of creating and maintaining a disaster-resistant landscape in public rights-of-way.)
- Buried/protected power and utility lines. (NOTE: Where appropriate. Burial may cause additional problems and costs in case of breakage, due to the increased difficulty in locating and repairing the problem.)
- Moving vehicles into garages or other covered areas.
- Inclusion of safety strategies for severe weather events in driver education classes and materials.
- Purchase of insurance that includes coverage for hail damage.
- Using structural bracing, window shutters, laminated glass in window panes, and impact-resistant roof shingles to minimize damage to public and private structures.

Tie-in with Local Hazard Mitigation Planning

Because many means of implementing mitigation actions occur through local activities, this updated MHMP places additional emphasis on the coordination of State-level planning and initiatives with those taking place at the local level. This takes two forms:

1. The provision of guidance, encouragement, and incentives to local governments by the State, to promote local plan development, and
2. The consideration of information contained in local hazard mitigation plans when developing State plans and mitigation priorities.

Regarding the first type of State-local planning coordination, MSP guidance has included the "Local Hazard Mitigation Planning Workbook" (EMD-PUB 207), which is currently being updated for release by 2015. For the second type of State-local planning coordination, a section later in this plan summarizes hazard priority information as it has been reported in local hazard mitigation plans. Here, it will merely be noted that hail was identified as one of the most significant hazards in local hazard mitigation plans for the following counties: Antrim, Arenac, Clare, Genesee, Gratiot, Huron, Lapeer, Mackinac, Monroe, Ogemaw, Roscommon, Shiawassee, Washtenaw (13 counties, total).

Lightning

The discharge of electricity from within a thunderstorm.

Hazard Description

Lightning is a random and unpredictable product of a thunderstorm's tremendous energy. The energy in the storm produces an intense electrical field like a giant battery, with the positive charge concentrated at one end and the opposite charge concentrated at the other. Lightning strikes when a thunderstorm's electrical potential (the difference between its positive and negative charges) becomes great enough to overcome the resistance of the surrounding air. Bridging that difference, lightning can jump from cloud to cloud, cloud to ground, ground to cloud, or even from the cloud to the air surrounding the thunderstorm. Lightning strikes can generate current levels of 30,000 to 40,000 amperes, with air temperatures often superheated to higher than 50,000 degrees Fahrenheit (hotter than the surface of the sun) and speeds approaching one-third the speed of light.

Hazard Analysis

Globally, there are about 2,000 thunderstorms occurring at any given time, and those thunderstorms cause approximately 100 lightning strikes upon the ground each second. In the United States, approximately 100,000 thunderstorms occur each year, and every one of those storms generates lightning. It is not uncommon for a single thunderstorm to produce hundreds or even thousands of lightning strikes. However, to the majority of the general public, lightning is perceived as a minor hazard. That perception lingers despite the fact that lightning damages many structures and kills and injures more people in the United States per year, on average, than tornadoes or hurricanes. Many lightning deaths and injuries could be avoided if people would have more respect for the threat lightning presents to their safety.

Lightning deaths are usually caused by the electrical force shocking the heart into cardiac arrest or throwing the heartbeat out of its usual rhythm. Lightning can also cut off breathing by paralyzing the chest muscles or damaging the respiratory center in the brain stem. It takes only about one-hundredth of an ampere of electric current to stop the human heartbeat or send it into ventricular fibrillation. Lightning can also cause severe skin burns that can lead to death if complications from infection set in.

As an indicator of the circumstances involving lightning fatalities, injuries and damage in the United States, consider the following statistics compiled by the National Oceanic and Atmospheric Administration (NOAA) and the National Lightning Safety Institute (NLSI) for the period of 1959-1994:

<u>Location of Lightning Strikes</u>

- 40% are at unspecified locations
- 27% occur in open fields and recreation areas (not including golf courses)
- 14% occur to someone under a tree (not including golf courses)
- 8% are water-related (boating, fishing, swimming, etc.)
- 5% are golf-related (on golf course or under tree on golf course)
- 3% are related to heavy equipment and machinery
- 2.4% are telephone-related
- 0.7% are radio, transmitter and antenna-related

<u>Gender of Victims</u>

- 84% are male; 16% are female

<u>Months of Most Strikes</u>

- July (30%); August (22%); June (21%)

<u>Most Likely Time Period of Reported Strikes</u>

- 2:00 PM – 6:00 PM

Number of Victims

- One victim (91%); two or more victims (9%)

The NLSI has estimated that 85% of lightning victims are children and young men (ages 10-35) engaged in recreation or work-related activities. Approximately 20% of lightning strike victims die, and 70% of survivors suffer serious long-term after-effects such as memory and attention deficits, sleep disturbance, fatigue, dizziness, and numbness.

Lightning can be especially damaging for electrical infrastructure, causing localized power outages and damage to phone lines and communication systems. Computers are also especially vulnerable to lightning strikes. In terms of property losses from lightning, statistics vary widely according to source. The Insurance Information Institute (a national clearinghouse of insurance industry information) estimates that lightning damage amounts to nearly 5% of all paid insurance claims, with residential claims alone exceeding $1 billion. Information from insurance companies shows one homeowner's damage claim for every 57 lightning strikes. The NLSI has estimated that lightning causes more than 26,000 fires annually, with damage to property exceeding $5-6 billion. Electric utility companies across the country estimate as much as $1 billion per year in damaged equipment and lost revenue from lightning. The Federal Aviation Administration (FAA) reports approximately $2 billion per year in airline industry operating costs and passenger delays from lightning. Because lightning-related damage information is compiled by so many different sources, using widely varying collection methods and criteria, it is difficult to determine a collective damage figure for the U.S. from lightning. However, annual lightning-related property damages are conservatively estimated at several billion dollars per year, and those losses are expected to continue to grow as the use of computers and other lightning-sensitive electronic components becomes more prevalent.

Lightning-Related Impacts on Michigan

Unfortunately, lightning has taken a tremendous toll on Michigan's citizens in terms of injury and loss of life. According to National Weather Service records through the mid-2000s, Michigan had incurred 101 lightning deaths, 711 lightning injuries, and 810 lightning casualties (deaths and injuries combined) – consistently ranking it near the top of the nation in all three categories. During the period 1959-1995 (the last period for which composite statistics were available), Michigan was ranked 2nd nationally (behind Florida) in lightning injuries, 12th nationally in lightning deaths, and 2nd nationally (again, behind Florida) in lightning casualties. Undoubtedly, the fact that Michigan is an outdoor recreation-oriented state contributes heavily to its high lightning death and injury tolls. As the following tables indicate, Michigan's lightning deaths and injuries were fairly consistent with the national trends in terms of the location of deadly or injury-causing strikes. More recent data suggests some improvement in Michigan's statistics, ranking it #13 in number of lightning deaths (11) between the years 1998 and 2008.

Lightning-Related Deaths in Michigan: 1959-July 2005

LIGHTNING DEATHS: 101		
Number of Deaths	**Location**	**Percent of Total**
29	Open fields, ball fields	29%
26	Under trees (not golf)	26%
11	Boats / water-related	11%
10	Golf course	10%
4	Near tractors / heavy equipment	4%
2	At telephone	2%
19	Other location / unknown	19%

Source: Storm Data, National Climatic Data Center

Lightning History for Michigan Counties – arranged by region – Jan. 1996 to Oct. 2013
(The Lower Peninsula regions are ordered by "tiers" from south to north, west to east)
Please refer to the Michigan Profile Map section for an explanation of regional divisions

COUNTY or area	**Lightning Events**	**Days with Event**	**Total property damage**	**Injuries**	**Deaths**
Washtenaw	20	18	$1,820,000	4	1
Wayne	20	16	$557,000	18	3
.Livingston	12	12	$1,844,000	1	
Oakland	39	33	$2,318,000	5	1
Macomb	25	19	$2,927,000	7	
5 County Metro region	23 avg.	20 avg.	$9,466,000	35	5
Berrien	3	3	$840,000	1	
Cass					
St. Joseph	5	5	$30,000	2	1
Branch					
Hillsdale	1	1			1
Lenawee	18	14	$880,000		1
Monroe	8	7	$143,000	2	
.Van Buren	2	2	$200,000	2	
Kalamazoo	3	3	$20,000	10	
Calhoun	1	1	$11,000		
Jackson					
.Allegan					
Barry	1	1		1	
Eaton					
Ingham					
.Ottawa	3	3	$60,000	1	
Kent	3	3	$1,000,000		
Ionia	1	1		1	
Clinton					
Shiawassee	6	6	$225,000	1	
Genesee	14	14	$220,500	11	1
Lapeer	9	6	$1,328,000	4	
St. Clair	6	6	$28,000	1	
.Muskegon	1	1	$40,000		
Montcalm	1	1		4	
Gratiot					
Saginaw	7	6	$202,500		
Tuscola	1	1	$100,000		
Sanilac	5	4	$145,000		
.Mecosta	2	2	$50,000	4	
Isabella	1	1	$10,000		
Midland	6	6	$70,000		
Bay	5	4	$63,000		
Huron	3	3	$535,000		
34 County S Lower Peninsula	3 avg.	3 avg.	$6,201,000	45	4

Continued on next page…

Part 2 of Michigan County Lightning History table

.Oceana					
Newaygo	1	1	$100,000		
.Mason					
Lake					
Osceola					
Clare	1	1	$5,000		
Gladwin	1	1		6	1
Arenac	1	1	$500		
.Manistee	1	1			
Wexford	1	1			
Missaukee	3	3	$1,000	2	
Roscommon	2	2	$55,000		
Ogemaw	1	1			
Iosco	3	3	$15,000	6	
.Benzie	1	1			
Grand Traverse	6	4	$170,000	1	1
Kalkaska	2	2		1	
Crawford	1	1		1	
Oscoda	2	2		1	2
Alcona					
.Leelanau	2	2	$40,000		
Antrim	2	2	$80,000		
Otsego	4	4	$503,000		
Montmorency					
Alpena	1	1		1	
.Charlevoix	1	1			
Emmet	1	1	$4,000		
Cheboygan	2	2	$75,000	1	
Presque Isle	2	2	$4,000		
29 Co N Lower Pn	1.5 avg.	1.4 avg.	$1,052,500	20	4
Gogebic	2	2		1	1
Iron	1	1	$50,000		
Ontonagon					
Houghton	2	2	$25,000		
Keweenaw					
Baraga					
.Marquette	4	4	$41,000		
Dickinson	3	3	$171,000		
Menominee					
Delta					
Schoolcraft					
Alger	2	2		3	1
.Luce	1	1	$70,000		
Mackinac	1	1	$150,000		
Chippewa	1	1	$2,800		
15 Co Upp.Pen	1.1 avg.	1.1 avg.	$509,800	4	2
MICHIGAN TOTAL	291	177	$17,229,300	104	15

Although Michigan's counties experience from about 20 to 40 thunderstorm days per year, there are a smaller number of known damaging lightning events per year (about 16 such events per year, on average). Michigan's average deaths from lightning are approximately 1 per year, and injuries average about 6 per year. Property damage from major events totals over $17 million since 1996 – averaging nearly $1 million per year. (Data from the National Climatic Data Center have been used to calculate these statistics.) Although an analysis by Global Atmospherics, Inc. had determined that Southwestern Michigan has the highest rate of lightning strikes, with a strike ratio of 4 flashes/km²/yr, the Southeastern part has a much greater rate of damaging lightning events, as shown in the NCDC summary tables on the previous pages. For comparison, the Global Atmospherics study determined that locations south of Midland have strike ratios of 3 flashes/km²/yr, and areas north of Midland have strike ratios of 2 flashes/km²/yr, including the Upper Peninsula. In terms of NCDC damaging incidents, though, southeast Michigan counties average at least 1 damaging event per year, but the rest of the state averages about one-tenth of this rate. The data reveals some correlation between urbanized land uses and lightning vulnerability, which makes sense from the perspective that a location that is hit in an urban area is more likely to have humans and property in or near that location, to be harmed. But there is also a greater incidence of lightning damage specifically within the southeastern counties, as a result of weather patterns and not just the level of development present there.

Lightning-Related Injuries in Michigan: 1959-July 2005

LIGHTNING INJURIES: 711		
Number of Injuries	**Location**	**Percent of Total**
243	Open fields, ball fields	34%
104	Under trees (not golf)	15%
35	Golf course	5%
26	Boats / water-related	4%
19	At telephone	3%
20	Near tractors / heavy equipment	3%
264	Other location / unknown	37%

Source: Storm Data, National Climatic Data Center

Because it is virtually impossible to provide complete protection to individuals and structures from lightning, this hazard will continue to be a problem for Michigan's residents and communities. However, lightning deaths, injuries, and property damage can be reduced through a combination of public education, human vigilance, technology, proper building safety provisions, and simple common sense.

Large outdoor gatherings (e.g., sporting events, concerts, campgrounds, fairs, festivals, etc.) are particularly vulnerable to lightning strikes that could result in many deaths and injuries. This vulnerability underscores the importance of developing site-specific emergency procedures for these types of events, with particular emphasis on adequate early detection, monitoring, and warning of approaching thunderstorms. Early detection, monitoring, and warning of lightning hazards, combined with prudent protective actions, can greatly reduce the likelihood of lightning injuries and deaths. In addition, close coordination between event organizers, local emergency management officials, and response agencies (i.e., police, fire, emergency medical care) can help prevent unnecessary (and often tragic) delays and mistakes in rendering care should a lightning incident occur.

Impact on the Public

Lightning has a discouraging effect on outdoor activities, and has also caused casualties (including death) and severe property damage, including the ignition of structural fires and wildfires, which in turn present serious additional risks and harm to the public and its property. Electrical and communications infrastructure can be affected by lightning strikes, causing widespread inconvenience and, in some cases, life-threatening impairment of needed medical equipment and emergency response.

Impact on Public Confidence in State Governance

When lightning causes infrastructure failure, a question may be raised about the adequacy of that infrastructure, its maintenance, and its design and regulation. In events that require mass sheltering, such as schools or large gatherings (e.g. a county fair or community-sponsored event), the ability of local and state government to adequately plan for severe weather is often vital to the success of such events, which themselves are often important for various sectors of the local and state economy. Citizen discontent and media-exacerbated controversies have arisen from situations in which inadequate planning was evident, or provisions for public sheltering were inadequate.

Impact on Responders

Responders tend to be working outdoors in conditions from which most residents are taking shelter. Although special training and safety precautions have usually been taken (e.g. for line-repair workers), nevertheless, responders are more exposed to and at-risk from lightning. This makes the use of various equipment more difficult and inhibits the ability of responders to work safely outdoors.

Impact on the Environment

Trees can be blown apart completely if struck by lightning, or have branches and bark broken off that can scar and even kill them. Lightning can cause trees and natural vegetation to catch fire, and large wildfires (q.v.) can be devastating upon an area's short-term ecological condition. Dry lightning is lightning that occurs with no precipitation at ground level, and this type of lightning is the most common natural cause of wildfires. Humans and wildlife can both be killed or injured when struck by lightning, and smoke from wildfires is unhealthy to breathe.

Significant Lightning Incidents

As one might expect in a state with a high number of lightning deaths and injuries, lightning incidents involving one individual are fairly common in Michigan. However, lightning incidents involving groups of individuals also take place. Over the past 35 years, numerous lightning incidents in Michigan have resulted in multiple injuries:

Significant Lightning Incidents in Michigan

August 23, 1975 – Leslie (Ingham County)

Ninety people were injured, one seriously, when lightning struck a campground during a severe thunderstorm.

June 20, 1979 – Camp Grayling (Crawford County)

Forty-five National Guardsmen were injured and three of them hospitalized when lightning struck a mess tent during a training mission.

July 7, 1994 – Potterville (Eaton County)

Lightning struck a swimming lake at Fox Memorial Park near Potterville, injuring 22 people (one critically). This strike seemingly came from "out of the blue." That is, there was not a storm actually overhead when it occurred. This is why waters need to be evacuated when there is any indication of lightning nearby.

June 21, 1995 – Ishpeming (Marquette County)

Although no one was injured in this event, a lightning strike caused a fire that destroyed a 100-year old church in downtown Ishpeming, with damages estimated at over a million dollars. Lightning also destroyed the chimney of a downtown house there, during the same storm event.

July 18, 1996 – Gladwin (Gladwin County)

A single bolt of lightning from a distant thunderstorm struck and killed the pitcher in a men's league softball game. Several in the infield were knocked to the ground by the lightning and three were taken to the hospital that day.

June 21, 1997 – Otisville (Genesee County)

After lightning struck a building that was housing a children's event, eight children were taken to the hospital with complaints of numbness and tingling. Fortunately, none of the injuries appeared to be serious.

July 26, 1997 – Farmington Hills (Oakland County)

$750,000 in damage was caused when lightning started a fire in a two-story apartment building.

September 19, 1997 – Southern Lower Peninsula (Midland, Van Buren, Barry, and Kalamazoo Counties)

Lightning struck a farm near Coleman (Midland County), killing 4 horses and doing $10,000 in damage. Lightning also damaged 2 houses in Waterford Township (Oakland County) and an apartment building in Westland (Wayne County). The South Haven Community Hospital (Van Buren County) received a direct lightning strike on its radio tower, disabling communications there ($200,000 damage). A young boy received minor injuries at Hastings (Barry County) when lightning struck near him. Lightning started a house fire in Climax Township (Kalamazoo County), resulting in $20,000 of damage.

June 16, 1998 – Southern Lower Peninsula (Wayne, Washtenaw, and Kent Counties)

A severe thunderstorm developed and a great amount of lighting was produced. A man was killed by lightning when walking to his car in Detroit, and a woman and boy were injured by a lightning strike at a Little League game in Taylor (Wayne County). A transmitting antenna for a radio station in the Hudson Mills area (Washtenaw County) was struck and had to be replaced (about $100,000 damage). A Livonia residence suffered significant damage from a lightning strike (about $2,000 in damage). In Alto (Kent County), lightning started a fire that destroyed a new educational building at a church.

July 21, 1998 – Southern Lower Peninsula (Muskegon, Kent, Macomb, and Wayne Counties)

Severe thunderstorms brought severe winds and frequent lightning to both the east and west parts of the southern Lower Peninsula. In the west, the counties of Muskegon, Kent, and Ottawa suffered more than a half-million dollars of damage from lightning strikes, which caused several major fires. In Muskegon County, lightning caused an attic fire in a house ($40,000 damage) in Muskegon Township, a fire in a storage building in Egelston Township, and power outages that affected 7,500 persons. In Kent County, more than $500,000 in damage resulted from a lightning-caused fire that heavily damaged an apartment building in Grand Rapids, destroying six apartments on the top floor and damaging at least 10 additional apartments when the roof caved in. 15,000 homes lost electricity throughout the Grand Rapids metro area, mostly caused by lightning strikes. The southeastern part of the state was even more heavily impacted by these thunderstorms,

resulting in state and federal disaster declarations in Wayne and Macomb County. The storms produced over 4,300 cloud-to-ground lightning strikes, some of which caused fires that destroyed a house and an apartment building, leaving 16 persons homeless and causing $275,000 in damage in Sterling Heights (Macomb County). In Waterford Township (Oakland County), a woman was hospitalized after being struck by lightning in a park.

August 10, 1998 – Brighton (Livingston County)

Thunderstorm-produced lightning struck a store northwest of Brighton. The resulting fire destroyed the building ($1.5 million in damage).

May 11, 2000 – Northville (Wayne County)

Lightning struck at a soccer field as a group was headed for shelter, knocking several persons down and requiring a 12-year-old boy to be hospitalized. Later that evening, lightning struck a tree in Dearborn Heights, and a man working nearby was struck by a limb from the tree, resulting in injuries which hospitalized him.

May 18, 2000 – Detroit Metro Airport (Wayne County)

Lightning struck the steel superstructure of a new terminal under construction at Detroit Metropolitan Airport, injuring nine workers (two requiring hospitalization).

July 27-28, 2000 – Southeast Michigan (Macomb, Lapeer, Sanilac Counties)

Near Romeo (Macomb County), a lightning strike started a fire that destroyed an automall on July 28 ($1 million damage). The previous day, lightning caused a fire that destroyed a manufacturing building and damaged a nearby company structure in Dryden (Lapeer County, $650,000 damage). In the Sandusky area (Sanilac County), a lightning-produced fire partially destroyed a barn ($15,000 damage).

December 11, 2000 – Ann Arbor (Washtenaw County)

Northwest of Ann Arbor, $1.1 million in property damage resulted when lightning caused a large home to be destroyed in the middle of a winter storm emergency.

June 12, 2001 – Benton Harbor (Berrien County)

Lightning struck an apartment complex in Benton Township, resulting in 35 residents being evacuated. The total property damage from the fire was $800,000.

September 19, 2002 – Ann Arbor (Washtenaw County)

One roofer was killed and two others were badly injured in Ann Arbor when they were hit by lightning during a thunderstorm.

July 4, 2003 – Oscoda (Iosco County)

During thunderstorms, lightning destroyed a large business sign whose fragments damaged nearby vehicles. One car had four occupants injured by shattering glass, and damages were estimated at $10,000.

July 16, 2005 – Macomb Township (Macomb County)

One house was completely destroyed by fire as the result of a lightning strike. Five additional house fires started in the areas of 22 and 23 Mile Roads, due to other lightning strikes from the same storm event. Total damages amounted to about a million dollars.

July 17, 2006 – Southeastern Michigan (Saginaw and Wayne Counties)

Intense thunderstorms produced lightning that seriously damaged a Church bell tower in Saginaw ($106,000 damage), and caused one injury and one death in the central-city area of Wayne County, when a couple sought refuge outdoors by going under a tree, which was then struck during the storm.

July 22, 2009 – Big Rapids (Mecosta County) and Gaylord (Otsego County)

At 8:45 am, a non-severe thunderstorm caused lightning to strike pine trees at Ferris State University, as four construction workers were standing nearby. All four workers were injured. That same afternoon, a lightning strike 1 mile north of Gaylord ignited a fire that rapidly spread through the Alpine Haus apartment complex, destroying it and leaving 52 persons without housing. Fortunately, no one was hurt in the apartment fire, but damages were estimated at $500,000.

July 15, 2010 – Vestaburg (Montcalm County)

Lightning struck four young persons between 9 and 18 years of age at a baseball diamond near Vestaburg. Fortunately, all survived the incident, but their injuries required special emergency care, including emergency medical flights to the appropriate care facilities.

September 21, 2010 – Kent County

Various fire departments reported that about a dozen house fires were ignited, in an area from Ada south to Caledonia, by lightning strikes produced by severe storms during the late afternoon.

April 26, 2011 – Portage (Kalamazoo County)

Nine people were injured and sent to the hospital (one severe) after lightning struck at a soccer field in Westfield Park (Portage). One man went into cardiac arrest but was able to be treated at a nearby hospital and released. The ages of the victims ranged from 12 to 41.

September 3, 2011 – Ann Arbor (Washtenaw County)

Michigan Stadium (with a capacity of over 100,000 people) was evacuated during a football game, due to a thunderstorm. The game was eventually called off in the third quarter, due to the strong winds, heavy downpours of rain, and several lightning strikes.

June 18, 2012 – Ellsworth (Antrim County)

Lightning struck a home in Banks Township, and the resulting fire destroyed the home (causing about $80,000 in damage).

Programs and Initiatives

Unfortunately, lightning prevention or protection, in an absolute sense, is impossible. However, the consequences of lightning strikes have been diminished (both in terms of deaths and injuries and property damage) through the implementation of the following programs and special initiatives:

National Weather Service Education

The National Weather Service issues severe thunderstorm watches and warnings when there is a threat of severe thunderstorms. However, lightning, by itself, is not sufficient criteria for the issuance of a watch or warning (every storm would require a watch or warning). The National Weather Service has an extensive public information program aimed at educating citizens about the dangers of lightning and ways to prevent lightning-related deaths and injuries.

Severe Weather Awareness Week

Each spring, the Emergency Management and Homeland Security Division, Michigan Department of State Police, in conjunction with the Michigan Committee for Severe Weather Awareness, sponsors Severe Weather Awareness Week. This annual public information and education campaign focuses on such severe weather events as tornadoes,

thunderstorms, hail, high winds, flooding and lightning. Informational materials on lightning hazards are disseminated to schools, hospitals, nursing homes, other interested community groups and facilities, and the general public.

Lightning Protection for Structures

The National Lightning Safety Institute (NLSI) has identified a systematic lightning hazard mitigation approach that can be followed to protect structures from lightning damage. That approach attempts to mitigate both the direct and indirect effects of lightning strikes through the application of appropriate structural safety improvements, as identified in a comprehensive lightning safety analysis. Full details of this mitigation approach can be obtained on a web page for NLSI.

National Lightning Detection Network

Despite advancements in electric power system design and equipment, lightning continues to be the single largest cause of outages on electrical distribution and transmission lines. To help combat that problem, the National Lightning Detection Network (NLDN) – a technologically advanced lightning location system operated by a private company in Phoenix, Arizona – was invented. The NLDN helps electric utilities make effective decisions regarding line maintenance priorities, crew dispatch, and future design and placement of utility transmission lines and lightning protection. NLDN lightning data is available in both real-time and archival format (1989-present). The lightning information from NLDN might lead to significant savings in utility maintenance and construction budgets, improved design and placement of future transmission and distribution infrastructure, and reduced outages due to lightning-related damage. Data from the NLDN can also be used to improve the safety of participants at outdoor events such as golf tournaments, air shows, fairs and outdoor festivals, and sporting events and concerts at outdoor stadiums and racetracks.

Local Lightning Detection Systems

Local lightning detection systems are increasingly being installed at golf courses, parks, pools, sports fields and stadiums, and other outdoor venues. These detection devices monitor electrical activity in the atmosphere and identify when favorable lightning conditions exist by activating a warning light or horn. That early warning can give local officials the time necessary to clear outdoor areas before actual lightning strikes occur.

Lightning Risk Calculator for buildings

Since lightning is an isolated phenomenon that causes great damage to a limited area and minimal damage to the structures adjacent to the lightning strike, it is necessary to determine lightning risks for some of the important buildings in your community. This is in addition to the general risk assessment of lightning strikes per year for a given county in the state. One way to calculate the risk of lightning strikes for a type of structure in your area is by using an on-line "Lightning Risk Calculator" from HLP Systems, Inc. at http://www.apltd.com/cgi-local/aestiva/start.cgi/riskhlp.htm. This lightning calculator examines the risk associated with various types of building sizes, materials, heights, uses, and roof types. It is not a foolproof source for assessing lightning risks for buildings in your community, but it does provide a simple way to begin to look at how some areas may be affected by lightning strikes.

Hazard Mitigation Alternatives for Lightning

- Increased coverage and use of NOAA Weather Radio.
- Public early warning systems and networks.
- Tree trimming and maintenance to prevent limb breakage and safeguard nearby utility lines. (Ideal: Establishment of a community forestry program with a main goal of creating and maintaining a disaster-resistant landscape in public rights-of-way.)
- Buried/protected power and utility lines. (NOTE: Where appropriate. Burial may cause additional problems and costs in case of breakage, due to the increased difficulty in locating and repairing the problem.)
- Using surge protectors on critical electronic equipment.
- Installing lightning protection devices on the community's communications infrastructure.

Tie-in with Local Hazard Mitigation Planning

Because many means of implementing mitigation actions occur through local activities, this updated MHMP places additional emphasis on the coordination of State-level planning and initiatives with those taking place at the local level. This takes two forms:

1. The provision of guidance, encouragement, and incentives to local governments by the State, to promote local plan development, and
2. The consideration of information contained in local hazard mitigation plans when developing State plans and mitigation priorities.

Regarding the first type of State-local planning coordination, MSP guidance has included the "Local Hazard Mitigation Planning Workbook" (EMD-PUB 207), which is currently being updated for release by 2015. For the second type of State-local planning coordination, a section later in this plan summarizes hazard priority information as it has been reported in local hazard mitigation plans. Here, it will merely be noted that lightning was identified as one of the most significant hazards in local hazard mitigation plans for the following counties: Branch, Calhoun, Clare, Delta, Genesee, Huron, Lapeer, Mackinac, Ogemaw, Roscommon, Shiawassee, Washtenaw (12 counties).

Severe Winter Weather Hazards

Severe winter weather hazards include snowstorms, blizzards, extreme cold, and ice and sleet storms. As a northern state, Michigan is vulnerable to all of these winter hazards. Most of the severe winter weather events that occur in Michigan have their origin as Canadian and Arctic cold fronts that move across the state from the west or northwest, although some of the most significant winter storms have their origins from the southwest, in combination with Arctic air masses. As the maps on the following pages show, Michigan averages moderate to heavy snowfall and extreme cold, averaging 90-180 days per year below freezing in the Lower Peninsula, and over 180 days below freezing in most of the Upper Peninsula. (For record snowfall amounts and a description of Michigan's three general "regions," please refer to the relevant table and text in the Introduction to the Weather Hazards section in this plan.)

The snowstorms and ice and sleet storms sections that follow provide greater detail on those particular severe winter weather hazards. The extreme temperatures section provides a more detailed overview of the severe cold temperatures hazard.

Winter storm hazards plague Michigan annually from November to March, with the state being vulnerable to snowstorms and ice and sleet storms. No area of the state is immune to severe winter conditions that can clog or paralyze the transportation network, cause widespread power outages, and slow normal daily activities to a standstill. Each community should be prepared for the harsh landscape created by snow and ice extremes. One way to understand the approaching risks of winter weather comes in the form of daily forecasts, and winter watches and warnings from the National Weather Service. The website for the NWS is www.crh.noaa.gov, which covers all regions in Michigan. To obtain recent county-level historical data since 1993 for both severe snowstorms and ice and sleet storms, visit the National Climatic Data Center's Storm Event website,
http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwEvent~Storms

Winter Weather Hazards (General)

- Increased coverage and use of NOAA Weather Radio.
- Tree trimming and maintenance to prevent limb breakage and safeguard nearby utility lines. (Ideal: Establishment of a community forestry program with a main goal of creating and maintaining a disaster-resistant landscape in public rights-of-way.)
- Buried/protected power and utility lines, where appropriate.
- Establishing heating centers/shelters for vulnerable populations.

Emphasis in Local Hazard Mitigation Plans

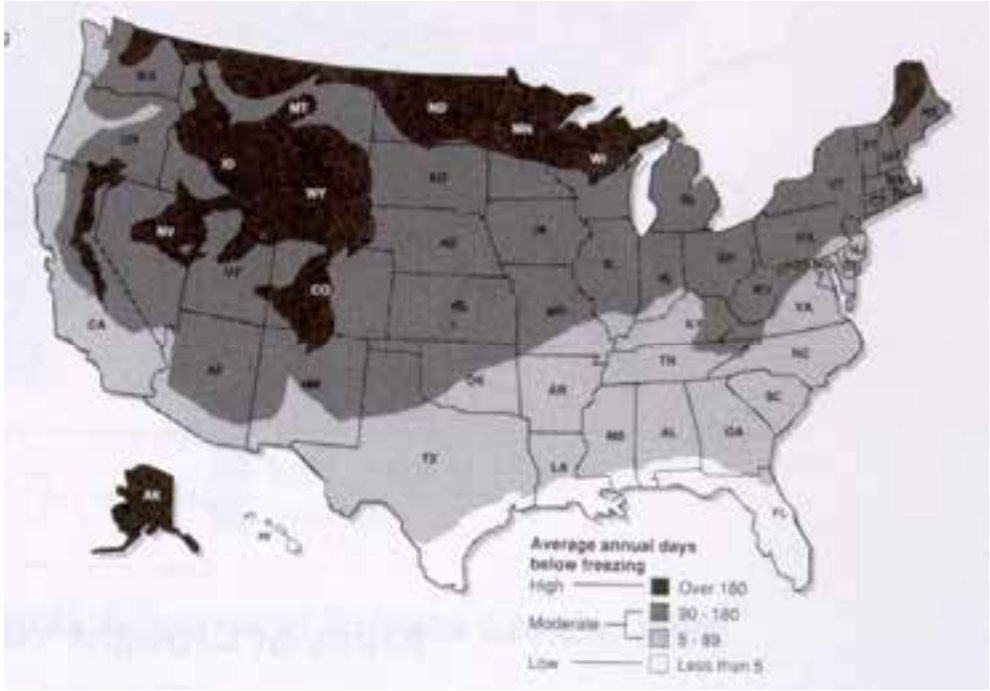
Severe Winter Weather was identified as one of the most significant hazard in local hazard mitigation plans for the following counties: Allegan, Alpena, Antrim, Barry, Bay, Benzie, Berrien, Branch, Calhoun, Cass, Charlevoix, Cheboygan, Chippewa, Delta, Emmet, Genesee, Grand Traverse, Gratiot, Hillsdale, Huron, Ionia, Isabella, Kalamazoo, Kalkaska, Kent, Lake, Lapeer, Leelanau, Luce, Macomb, Manistee, Marquette, Mason, Mecosta, Menominee, Midland, Missaukee, Monroe, Montcalm, Montmorency, Muskegon, Newaygo, Oceana, Ogemaw, Osceola, Oscoda, Otsego, Ottawa, Roscommon, Saginaw, Schoolcraft, Shiawassee, Tuscola, Van Buren, and Wexford.

To obtain recent county-level historical data since 1993 for both severe snowstorms and ice and sleet storms, visit the National Climatic Data Center's Storm Event website,
http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwEvent~Storms
and select a profile of your county's major winter storm history. The site has one category for severe "Snow and Ice" storms, but categorizes them separately once a particular county's information is accessed.

The following two sections will outline the risks for ice, sleet, and snowstorms.

Average Annual Days Below Freezing in the U.S.

Source: Council of State Governments; Federal Emergency Management Agency



Ice and Sleet Storms

A storm that generates sufficient quantities of ice or sleet to result in hazardous conditions and/or property damage.

Hazard Description

Although these two types of winter storms have been combined in this subsection, ice storms and sleet storms are two different phenomena. Ice storms, also known as freezing rain, coat roads, trees, power lines, and buildings with thick, heavy, and slick surfaces. Ice storms are sometimes incorrectly referred to as sleet storms. Sleet is small frozen rain drops (ice pellets) that bounce when hitting the ground or other objects. Sleet storms, which involve small pellets of ice accumulating on surfaces, are less dangerous than ice storms, but still cause potential harm to transportation and electrical systems. Sleet does not stick to trees and wires, but sleet in sufficient depth does cause hazardous driving conditions. Ice storms are the result of cold rain that freezes on contact with a surface, coating the ground, trees, buildings, overhead wires and other exposed objects with ice, sometimes causing extensive damage. When electric lines are downed, power may be out for several days, resulting in significant economic losses and the disruption of essential services in affected communities. Massive traffic accidents and power outages from downed tree limbs and utility lines are common when an ice storm occurs.

Ice storms usually have a regional effect and may influence all corners of Michigan. Groups of counties are usually affected instead of just one county. Often, ice storms are accompanied by snowfall, in which the ice is camouflaged and covered up by snow, creating treacherous transportation conditions. Both storms occur when the temperature is close to 32°F, but are far more severe when the temperature is in the 20s. The southern parts of the state have annual winter temperatures closer to 32°F, so the prevalence for ice and sleet storms seems more likely there than in the northern areas of the state. Events tend to be more severe when they occur as temperatures lower into the 20s.

Hazard Analysis

The table below illustrates the frequency distribution of ice and sleet storms in Michigan for the period 1970-July 2007. Approximately 81% of those storms occurred during the months of January, February, March and April, when conditions are most conducive for the development of ice and sleet. One-quarter of all ice and sleet storms in the period occurred during the month of March, and more than a quarter occurred in January.

By observing winter storm watches and warnings, adequate preparations can usually be made to reduce the impacts of ice and sleet conditions on Michigan communities. Providing for the mass care and sheltering of residents left without heat or electricity, and mobilizing sufficient resources to clear broken tree limbs from roadways, are the primary challenges facing community officials. Severe ice and sleet storms can affect every Michigan community. Ice storms usually have a regional effect and groups of communities are usually affected instead of just one community. Therefore, every community should plan and prepare for these emergencies. MSP/EMHSD staff has not yet found specific documentation on sleet and ice storms in the state to verify different vulnerabilities in different areas of the state. The southern parts of the state have annual winter temperatures closer to 32°F, so the prevalence for ice and sleet storms seems more likely there than in the northern areas of the state. Planning and preparedness efforts should include the identification of mass care facilities and necessary resources such as cots, blankets, food supplies and generators, as well as debris removal equipment and services. In addition, communities should develop debris management procedures (to include the identification of multiple debris storage, processing and disposal sites) so that the tree and other storm-related debris can be handled in the most expedient, efficient, and environmentally safe manner possible.

Frequency Distribution of Ice and Sleet Storms
in Michigan: 1970 – July 2007

JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	TOTAL
17	10	14	6	0	0	0	0	0	0	3	9	59
29%	17%	24%	10%	0%	0%	0%	0%	0%	0%	5%	15%	100%

Source: National Weather Service; Storm Data, National Climatic Data Center (percentages are rounded off)

Ice/Sleet Storm History for Michigan Counties – arranged by region – Jan. 1996 to Oct. 2013
(The Lower Peninsula regions are ordered by "tiers" from south to north, west to east)
Please refer to the Michigan Profile Map section for an explanation of regional divisions

COUNTY or area	Ice/Sleet Events	Tot. property damage	Tot. crop damage	Deaths	Injuries
Washtenaw	7	$3,400,000			1
Wayne	8	$5,000,000			1
.Livingston	7	$2,310,000			
Oakland	8	$104,452,000		1	2
Macomb	8	$54,325,000			
5 Co Metro region	**8 avg.**	**$169,487,000**		**1**	**4**
Berrien	9	$30,000			
Cass	9	$30,000			
St. Joseph	10	$30,000			
Branch	9				1
Hillsdale	9				
Lenawee	8	$2,530,000			
Monroe	8	$4,540,000			
.Van Buren	6	$25,000			
Kalamazoo	6	$75,000			
Calhoun	6	$30,000			
Jackson	6	$30,000			
.Allegan	6				
Barry	6	$25,000			
Eaton	7	$325,000			
Ingham	7	$340,000			
.Ottawa	8	$500,000			
Kent	8	$1,000,000			
Ionia	8	$330,000			
Clinton	7	$330,000			
Shiawassee	8				
Genesee	8	$110,000			
Lapeer	8	$1,075,000			
St. Clair	8	$10,100,000			
.Muskegon	6	$200,000			
Montcalm	8	$200,000			
Gratiot	7	$1,250,000	$5,000		
Saginaw	12	$1,010,000			
Tuscola	9	$20,000			
Sanilac	7	$30,000			
.Mecosta	8	$350,000	$5,000		
Isabella	8	$350,000	$5,000		
Midland	11				
Bay	11				
Huron	8	$25,000			
34 Co S Lower Pen	**8 avg.**	**$24,890,000**	**$15,000**		**1**

Continued on next page…

Part 2 of Ice/Sleet History for Michigan Counties – arranged by region

.Oceana	2	$200,000			
Newaygo	2	$200,000			
.Mason	1	$200,000			
Lake	1	$200,000			
Osceola	4	$450,000	$5,000		
Clare	4	$350,000	$5,000		
Gladwin	3	$60,000			
Arenac	2	$50,000			
.Manistee	4				
Wexford	3				
Missaukee	2				
Roscommon	3				
Ogemaw	3	$5,000			
Iosco	4	$50,000			
.Benzie	4				
Grand Traverse	4				
Kalkaska	4				
Crawford	1				
Oscoda	2				
Alcona	3				
.Leelanau	4				
Antrim	3				
Otsego	3				
Montmorency	3				
Alpena	2				
.Charlevoix	3				
Emmet	4				
Cheboygan	4				
Presque Isle	4				
29 Co N Lower Pen	**3 avg.**				
Gogebic	3				
Iron	3				
Ontonagon	3				
Houghton	1				
Keweenaw	2				
Baraga	3				
.Marquette	4				
Dickinson	5				
Menominee	4				
Delta	4				
Schoolcraft	4				
Alger	4				
.Luce	5				
Mackinac	3				
Chippewa	3				
15 Co Upper Pen					
MICHIGAN TOTAL	294	$196,142,000	$25,000	1	5

There is an average of about 15 significant storm events in Michigan each year (not all of which are direct damaging on a community level). Many events are multi-county events, with damages from a wide area merely estimated within each country, and therefore the state and county totals in the table may not add together neatly. Many ice storm deaths are actually caused by automobile accidents, heart attacks from overexertion, downed power lines, carbon monoxide

poisoning, and other secondary effects that may be difficult to distinguish from other causes. In terms of property damage, major ice storm events have, according to NCDC records, caused about $200 million in damages since 1996 (averaging about $10 million per year), and the April 2003 ice storm was particularly severe, reportedly causing half that amount in itself. Geographically, a clear pattern is evident in the table—these events are most frequent in the southern Lower Peninsula, and become much less common in northern parts of the state. Damages from ice/sleet hazards were not even reported in NCDC records for the Upper Peninsula or the northernmost counties in the Lower Peninsula. The records indicate property and crop damage only in Michigan counties located south of the 45th Parallel. However, it is assumed that any events listed in NCDC were serious enough that they had the potential to do damage; the lack of damage reports for the past 20 years should not suggest that ice/sleet damage is impossible, but merely less likely according to the historical records.

Impact on the Public

Ice and sleet storms tend to cause power or other infrastructure failures that interfere with residents' activities, comfort, and safety (often through the impact of infrastructure failures on needed medical and emergency response capabilities). Direct physical effects may include frostbite, hypothermia, and other medical conditions, and thus require some citizens to be provided with warm clothing and shelter. Certain types of building designs are susceptible to structural failure from the accumulation of ice or snow on their roofs. Traffic efficiency and road capacity tends to be impeded by these weather events, which cause a large increase in the risks involved in all modes of travel. Injurious accidents may include simple pedestrian falls (due to the difficulty of balancing and walking on ice-coated surfaces), or large-scale transportation accidents (such as multi-car interstate pileups).

Impact on Public Confidence in State Governance

For this hazard, the main issues regarding public confidence in government predominantly involve: (1) the ability of the infrastructure of the impacted area to withstand the ice or sleet event and continue to serve area residents, and (2) the ability of the government(s) to efficiently clear away ice and sleet from areas that are most vitally needed for transportation and other shared public uses (e.g. schools, hospitals). If any shortcomings or failures in one or both of these functions are too evident to citizens (or mass media providers), then the capacity, efficiency, and adequacy of government(s) may be called into question. In many areas, the State and different forms of local governments and agencies will have different types of responsibilities, and where problems arise in the coordination or clarity of these governments' actions and responsibilities, discontent can reasonably be expected to be expressed by citizens.

Impact on Responders

Responders are asked to be outdoors during winter weather events in which most citizens prefer to take shelter. In addition to the risks from winds, obscured vision, impaired control of vehicles, power failures and blocked roadways, winter storm events also expose responders to extremely cold temperatures for long periods of time, and may thus compound the difficulties, risks, and expenses of response. Fatigue can more easily become a problem under extreme temperature conditions, either during winter weather emergencies or during extreme summer heat and humidity. Icy conditions make various travel and outdoor operations treacherous.

Impact on the Environment

Freezing rain drops (sleet) and dangerous ice storms coat surfaces with layers of ice and can also affect the environment. Ice storms can damage trees, as the weight of accumulated ice brings down limbs and branches, or even entire trees. When soil is not frozen, ice loads can cause root damage to forest trees. An ice coating over widespread forest lands can destroy natural forest vegetation and disrupt species' habitats, species composition, and forest land diversity. Dried dead trees may be more prone to fire, contributing to wildfires in other seasons if not removed properly. Dead trees can become breeding areas for beetles and other pests that can harm the healthy green trees. Floods often occur when ice melts, and can cause environmental effects (as described in the flooding section).

Climate Change Considerations

Climate change effects seem likely to cause an increase in the number of ice and sleet storm events, at least across the southern part of Michigan. The reason involves average temperatures in and around the winter months that are closer to the freezing point, at which ice and sleet events typically occur. Instead of winter arriving and precipitation remaining as snow, Michigan has been seeing more thawing episodes, followed by refreezes which can cause treacherous ice cover upon frozen surfaces, weight down cables and tree branches, and cause breakages which lead to infrastructure failures. Even though Michigan's winter season has been shortening over time, winters remain

hazardous because the increasing level of precipitation more often takes the form of major snow events, and provides a lot more moisture for refreezing after warmer thawing periods.

Significant Ice and Sleet Storms in Michigan since 1976

March 2-7, 1976 – Central Lower Michigan

During the period from March 2-7, 1976 an ice storm with accompanying high winds and tornadoes struck a 29 county area in the central Lower Peninsula. This storm, one of the worst to ever hit the state, caused over $56 million in damage, and widespread power outages. The storm impacts were so severe that a Presidential Major Disaster Declaration was granted for the 29 affected counties, to assist in the recovery from the storm.

April 8, 1979 – Southern Lower Michigan

On April 8, 1979 an ice storm struck Lower Michigan south of a line from Grand Haven to Bay County. The storm left 240,000 utility customers without power for several days. In addition, numerous injuries resulted from the downed power lines.

January 1, 1985 – Southern Lower Michigan

On January 1, 1985 a severe ice storm struck a 13 county area in the southern Lower Peninsula. Freezing rain accumulating up to one inch in thickness downed tree limbs, trees and power lines, blocked roads, and caused widespread power outages. There were three deaths and eight injuries directly related to the ice storm. Approximately 13,000 homes and 260 businesses sustained damage or were destroyed, with losses estimated at nearly $25 million. Another 160 businesses lost inventory as a result of the storm damage and power outages. Over 430,000 electrical customers were without power, some for as long as 10 days. At the height of the power outage, 28 public shelters were opened to provide shelter to nearly 1,000 residents without power or heat. Several nursing homes and adult foster care facilities had to be evacuated due to the loss of power and heat. Total public and private damage from this ice storm was estimated at nearly $50 million. A Governor's Disaster Declaration was issued to mobilize state resources to assist in the storm response and recovery.

March 13-14, 1997 – Central and Southeast Michigan

In the late evening hours of March 13, 1997 an ice storm struck the central and southeastern Lower Peninsula, causing widespread power outages, icy roads, downed trees and numerous school closings. Many of the counties in the southern third of Michigan were impacted by the storm. North of Detroit, nearly all the precipitation fell in the form of freezing rain, in amounts ranging from 0.8 to 1.5 inches. Farther south, precipitation amounts ranged from 1.5 to nearly 2.5 inches. Macomb County damages amounted to about $4 million, Lenawee County totaled $1 million, as did Monroe County. Washtenaw damage tallies were $3 million, Oakland had $4 million in damage, as did Wayne County, and Livingston County suffered $2 million in damages. In the storm's aftermath, 514,000 Detroit Edison and Consumers Energy electrical customers were without power, several thousand of whom went without for as long as 4 days. Major outages occurred in Jackson, Kalamazoo, Cass, Branch, St. Joseph and Calhoun counties, as well as in Lansing. Many local communities opened shelters to accommodate residents unable to remain in their homes due to the lack of power. Response efforts were severely hampered by snow and windy conditions the following day. In addition to fallen power lines, falling trees damaged dozens of cars and houses throughout the area. Most schools were closed, and there were numerous auto accidents.

April 3-5, 2003 – West and Central Lower Michigan

A major ice storm affected much of southern Lower Michigan, causing hundreds of thousands of people to lose power. The weight of the ice brought down thousands of trees and limbs and hundreds of power lines. Many people across the area lost power for several days and some who lived in outlying areas were without power for a week. The ice storm resulted in several million dollars' worth of damage across the area. Most of the counties across the central and southern Lower Peninsula received a total of ½ to 1½ inches of ice. It was one of the biggest ice storms to affect lower Michigan in the previous 50 years. Damage totals amounted to $1 million in Kent County, $1 million in Lapeer County, $10 million in St. Clair County, $50 million in Macomb County, and $100 million in Oakland County, where 1 death and 2 injuries also occurred (due to falling trees and branches). Additional casualties stemmed from traffic accidents—about two dozen injuries and one death, the latter from a car skidding into a ditch filled with water. Three persons also died from carbon monoxide poisoning, due to the use of poorly ventilated generators.

February 16, 2006 – Central Lower Michigan

A major ice storm affected much of central Lower Michigan. There were numerous reports of ice accumulations up to one inch. This glazing caused widespread tree damage and thousands of power outages. Some people were without power for several days, resulting in the opening of numerous temporary shelters due to the extreme cold in the wake of the ice storm. Total damages were in excess of $2 million. $1 million in damage took place in Gratiot County, and $1 million in Saginaw County.

January 14-15, 2007 – Southern Lower Michigan

A major ice storm affected an area from the extreme southwestern part of Lower Michigan northeast into the Flint and Detroit metro areas. There were numerous reports of ice accumulations up to one half inch. This glazing caused widespread tree damage and over 150,000 structures to be without power. Total damages exceeded $2 million.

March 1-2, 2007 – Southeast Michigan

In Huron County, a high-impact ice storm resulted in ice accumulations up to 3 inches thick on power lines and trees. Other "Thumb" counties were also hard-hit. Most of the damage occurred between 10 pm on March 1 and 1am on March 2. Strong winds gusted to 50 mph and brought down trees and utility poles over many miles. More than half of Huron County's population was without power, some for up to 6 days. Hundreds sought shelter and were assisted by the American Red Cross. Hundreds of traffic accidents took place, including some that were serious and resulted in 6 injuries and one death. Property damage alone amounted to $1.5 million (mostly in Huron County).

February 20-21, 2011 – Lenawee and Monroe Counties

At the end of a large snowstorm (producing 5 to 10 inches of snow across the majority of southeast Michigan), the snow turned to ice near the Ohio border as a major ice storm occurred. Downed trees and power lines occurred across Lenawee and Monroe Counties, due to ice accumulations of ½ to 1 inch. Power outages lasted for up to 4 or 5 days. Property damage in Lenawee County amounted to $1.5 million, and $3.5 million in Monroe County.

Programs and Initiatives

Note: Many of the programs and initiatives designed to mitigate, prepare for, respond to, and recover from snowstorms have the dual purpose of also protecting against ice and sleet storms. As a result, there is some overlap in the narrative programs and initiatives descriptions for each respective hazard. This redundancy allows each hazard section to stand alone, eliminating the need to refer to other hazard sections for basic information.

<u>National Weather Service Doppler Radar</u>

The National Weather Service (NWS) has completed a major modernization program designed to improve the quality and reliability of weather forecasting. The keystone of this improvement is Doppler Weather Surveillance Radar,

which can more easily detect severe weather events that threaten life and property – including severe winter weather events such as ice and sleet storms. Most important, the lead time and specificity of warnings for severe weather have improved significantly.

National Weather Service Watches/Warnings

Sufficient warning can do much to reduce the damage from ice and sleet storms by permitting people to prepare properly. The National Weather Service uses the terms "ice storm," "freezing rain," and "freezing drizzle" to warn the public when a coating of ice is expected on the ground and on other exposed surfaces. The qualifying term "heavy" is used to indicate ice coating which, because of the extra weight of the ice, could cause significant damage to trees, overhead wires, and other exposed objects.

The State and local government agencies are warned via the Law Enforcement Information Network (LEIN), National Oceanic and Atmospheric Administration (NOAA) weather radio, and the Emergency Managers Weather Information Network (EMWIN). Public warning is provided through the Emergency Alert System (EAS). The National Weather Service stations in Michigan transmit information directly to radio and television stations, which in turn pass the warning on to the public. The National Weather Service also provides detailed warning information on the Internet, at www.weather.gov, where an interactive map can be used.

Winter Hazards Awareness Week

Each fall, the Emergency Management and Homeland Security Division, Department of State Police, in conjunction with the Michigan Committee for Severe Weather Awareness, sponsors Winter Hazards Awareness Week. This annual public information and education campaign focuses on winter weather hazard events such as snowstorms, blizzards, extreme cold, and ice and sleet storms. Informational materials on winter weather hazards and safety are disseminated to schools, hospitals, nursing homes, other interested community groups and facilities, and the general public.

Electrical Infrastructure Reliability

One of the major problems associated with ice storms is the loss of electric power. Michigan has had numerous widespread and severe electrical power outages caused by ice storms, several of which have resulted in a power loss to 250,000 – 500,000 electrical customers for several hours to several days at a time. Ice-related damage to electric power facilities and systems is a concern that is being actively addressed by utility companies across the state. Detroit Edison, Consumers Energy and other major electric utility companies have active, ongoing programs to improve system reliability and protect facilities from damage by ice, severe winds, and other hazards. Typically, these programs focus on trimming trees to prevent encroachment of overhead lines, strengthening vulnerable system components, protecting equipment from lightning strikes, and placing new distribution lines underground. The Michigan Public Service Commission (MPSC) monitors power system reliability to help minimize the scope and duration of power outages.

Urban Forestry/Tree Maintenance Programs

Urban forestry programs can be very effective in minimizing ice storm damage caused by falling trees or tree branches. In almost every ice storm, falling trees and branches cause power outages and clog public roadways with debris. However, a properly designed, managed and implemented urban forestry program can help keep tree-related damage and impact to a minimum. To be most effective, an urban forestry program should address tree maintenance in a comprehensive manner, from proper tree selection, to proper placement, to proper tree trimming and long-term care.

Every power company in Michigan has a tree trimming program, and numerous local communities have some type of tree maintenance program. The electrical utility tree trimming programs are aimed at preventing encroachment of trees and tree limbs within power line rights-of-way. Typically, professional tree management companies and utility work crews perform the trimming operations. At the local government level, only a handful of Michigan communities have actual urban forestry departments or agencies. Often, crews from the area public works agency or county road commission perform the bulk of the tree trimming work.

When proper pruning methods are employed, and when the work is done on a regular basis with the aim of reducing potential storm-related damage, these programs can be quite effective. Often, however, tree trimming work is deferred

when budgets get tight or other work is deemed a higher priority. When that occurs, the problem usually manifests itself in greater storm-related tree debris management problems down the line.

Hazard Mitigation Alternatives for Ice and Sleet Storms

- Increased coverage and use of NOAA Weather Radio.
- Tree trimming and maintenance to prevent limb breakage and safeguard nearby utility lines. (Ideal: Establishment of a community forestry program with a main goal of creating and maintaining a disaster-resistant landscape in public rights-of-way.)
- Buried/protected power and utility lines. (NOTE: Where appropriate. Burial may cause additional problems and costs in case of breakage, due to the increased difficulty in locating and repairing the problem.)
- Establishing heating centers/shelters for vulnerable populations.
- Home and public building design and maintenance to prevent roof and wall damage from "ice dams."

Tie-in with Local Hazard Mitigation Planning

Because many means of implementing mitigation actions occur through local activities, this updated MHMP places additional emphasis on the coordination of State-level planning and initiatives with those taking place at the local level. This takes two forms:

1. The provision of guidance, encouragement, and incentives to local governments by the State, to promote local plan development, and
2. The consideration of information contained in local hazard mitigation plans when developing State plans and mitigation priorities.

Regarding the first type of State-local planning coordination, MSP guidance has included the “Local Hazard Mitigation Planning Workbook” (EMD-PUB 207), which is currently being updated for release by 2015. For the second type of State-local planning coordination, a section later in this plan summarizes hazard priority information as it has been reported in local hazard mitigation plans. Here, it will merely be noted that ice/sleet was identified as one of the most significant hazards in local hazard mitigation plans for the following counties: Alger, Berrien, Cheboygan, Clinton, Delta, Genesee, Grand Traverse, Hillsdale, Jackson, Lake, Lapeer, Lenawee, Marquette, Mecosta, Schoolcraft, Tuscola. (Note: Most local plans did not sufficiently distinguish between ice, sleet, and snowstorms, and so this information should be used as an approximate indicator of local priorities for this hazard.)

Snowstorms

A period of rapid accumulation of snow often accompanied by high winds, cold temperatures, and low visibility.

Hazard Description

As a result of being surrounded by the Great Lakes, Michigan experiences large differences in snowfall over relatively short geographic distances. The average annual snowfall accumulation in different areas ranges from 30 to 200 inches of snow. The highest accumulations are in the northern and western parts of the Upper Peninsula, as some areas of Baraga and Houghton Counties receive over 200 inches of snow per year. In Lower Michigan, the highest snowfall accumulations occur near Lake Michigan and in the higher elevations of northern Lower Michigan. Areas in the northwest portion of the Lower Peninsula average greater than 120 inches of snow annually. On the low end of snowfall totals, areas in the east central and southeastern portions of the state receive less than 50 inches of snow per year. Communities in West Michigan typically receive 60-100 inches of snow.

Blizzards are the most dramatic and perilous of all snowstorms, characterized by low temperatures and strong winds (35+ miles per hour) bearing enormous amounts of snow. Most of the snow accompanying a blizzard is in the form of fine, powdery particles that are wind-blown in such great quantities that, at times, visibility is reduced to only a few feet. Blizzards have the potential to result in property damage and loss of life. Just the cost of clearing the snow can be enormous.

Snowstorms can be very dangerous for a community over a period of days or weeks. Heavy snows can shut down towns and cities for several days if snow is persistent and cannot be cleared in a timely fashion. Pre-planning for snow storage areas will be helpful. Roof failures may occur as the weight of the snow and area of snow cause damage to homes and buildings. Motorists and passengers in cars can be stranded in rural areas and die of exposure because of inadequate preparation for conditions.

Extreme snows are most likely in the Upper Peninsula and the northern sections of Lower Michigan. Areas in the northwest portion of the Lower Peninsula average greater than 120 inches of snow annually. The snow is more extreme in the Upper Peninsula, as some areas of Baraga and Houghton Counties receive over 200 inches of snow per year. On the low end of snowfall totals, areas in the east central and southeastern portions of the state receive less than 50 inches of snow per year. Communities in West Michigan typically receive 60-100 inches of snow. A map appears on the next page.

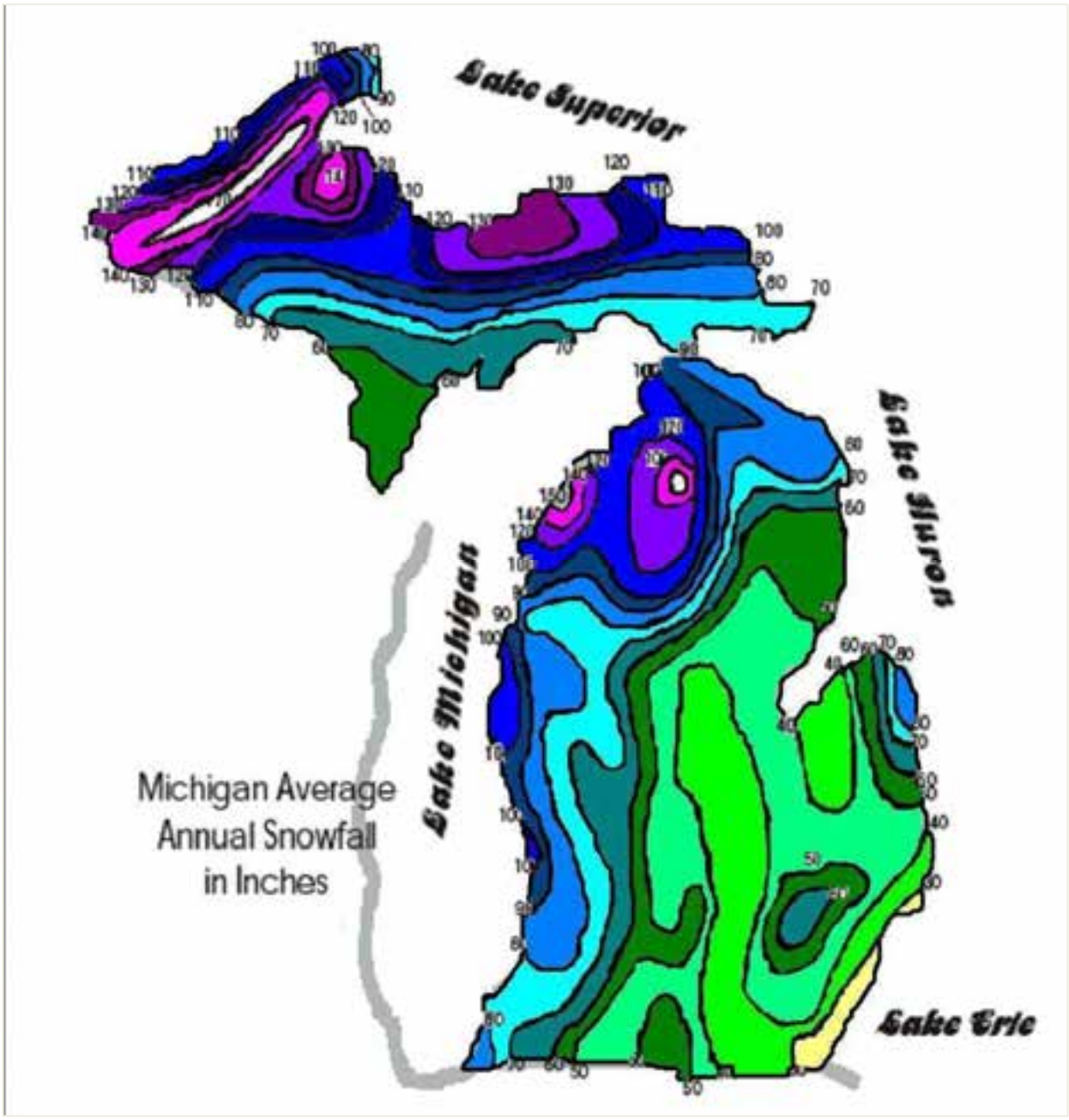
Urban areas can be especially susceptible to outages and problems with snow removal, due to their complexity and limited space for snow clearance and storage. Rural areas may have inaccessible roads for some time but often have residents that are more equipped to independently handling power outages and temporary isolation. Information about snow cover and types, which may be useful either for an analysis of the snowstorm hazard, or in an analysis of snowmelt-related flood risks, may be found at http://www.nohrsc.nws.gov.

Hazard Analysis

The snowfall map before the preceding section shows that the western Upper Peninsula experiences the most snowstorms and snowfall in Michigan each year. The western half of the Lower Peninsula also experiences heavy snowfall and a relatively large number of snowstorms. One reason for this is the "lake effect," a process by which cold winter air moving across Lakes Michigan and Superior picks up moisture from the warmer lake waters, resulting in larger snowfall amounts in the western part of the state.

Michigan Average Annual Snowfall

Source: Michigan Committee for Severe Weather Awareness



Please refer to the table in the Introduction to the Weather Hazards section to find a table of record snowfall amounts at various locations across Michigan, and for a description and comparison of the state's three general "regions," as defined in this document. In general, the snowstorm season of the Southern Lower Peninsula runs from November to April each year. (Although snow occasionally does fall outside of this "season," such snowfall would be comparatively light, rather than the sort of snowstorm event that is here being considered as a hazard.) The snowstorm season in the Northern Lower Peninsula runs from October to May. The snowstorm season for the Upper Peninsula runs from late September to May. This does not mean that all of these months necessarily receive significant snowfall each year. Instead, the "season" denotes the part of each year when a significant snowstorm may occur. A significant snowstorm is here defined as at least several inches of snow accumulation in a single event.

Snowstorm History for Michigan Counties – arranged by region – Jan. 1996 to Oct. 2013
(The Lower Peninsula regions are ordered by "tiers" from south to north, west to east)
Please refer to the Michigan Profile Map section for an explanation of regional divisions

COUNTY or area	Snow Storm Events	Days with Snow Storms	Tot. property damage	Tot. crop damage	Injuries	Deaths
Washtenaw	45	45	$225,000			
Wayne	38	38	$960,000			
.Livingston	47	47	$129,000		3	
Oakland	49	49	$400,000		3	
Macomb	43	43	$170,000			
5 Co Metro region	**44 avg.**	**44 avg.**	**Total $1,884,000**		**6**	
Berrien	83	83	$20,000			
Cass	72	71				
St. Joseph	42	42				
Branch	40	40				
Hillsdale	35	35				
Lenawee	42	40	$505,000			
Monroe	33	33	$45,000			
.Van Buren	111	111	$25,000			
Kalamazoo	73	73	$25,000			
Calhoun	52	52	$2,225,000			
Jackson	47	47	$1,200,000			
.Allegan	130	129	$25,000			
Barry	61	61	$25,000			
Eaton	45	46	$1,025,000			
Ingham	46	46	$1,025,000			
.Ottawa	122	122	$250,000			
Kent	87	87	$50,000			
Ionia	46	46	$25,000			
Clinton	40	40	$1,025,000			
Shiawassee	39	39	$10,000			
Genesee	49	49	$1,650,000		1	
Lapeer	46	46	$10,000			
St. Clair	57	57	$45,000			
.Muskegon	102	102				
Montcalm	58	57	$30,000			
Gratiot	46	45	$25,000			
Saginaw	48	48	$25,000			
Tuscola	46	46				
Sanilac	59	59	$5,000			
.Mecosta	56	55	$40,000			
Isabella	49	48	$290,000			
Midland	45	44				
Bay	46	45	$25,000			
Huron	54	54	$1,500,000			
34 Co S Lower Pen	**59 avg.**	**59 avg.**	**Total $11,150,000**		**1**	

Continued on next page…

Part 2 of Snowstorm History for Michigan Counties – arranged by region

.Oceana	100	99				
Newaygo	69	69	$25,000			
.Mason	99	98				
Lake	71	70	$375,000			
Osceola	56	55	$510,000			
Clare	52	51	$300,000			
Gladwin	35	35				
Arenac	38	38				
.Manistee	72	72	$350,000			
Wexford	57	57	$283,000			
Missaukee	63	63	$185,000			
Roscommon	52	52	$100,000			
Ogemaw	45	45	$50,000			
Iosco	42	41				
.Benzie	79	79	$600,000	$2,000,000		
Grand Traverse	93	93	$612,000	$5,000,000		
Kalkaska	106	106	$290,000			
Crawford	66	66	$255,000			
Oscoda	46	46	$100,000			
Alcona	39	39	$3,000			
.Leelanau	102	102	$653,000	$13,000,000		
Antrim	122	122	$250,000			
Otsego	101	100	$337,000			
Montmorency	48	48	$165,000			
Alpena	55	55	$110,000			
.Charlevoix	110	110	$295,000			
Emmet	91	91	$204,000			
Cheboygan	71	71	$206,000			
Presque Isle	55	55	$258,000			
29 Co N Lower Pen	**70 avg.**	**70 avg.**	**Total $6,516,000**	**$20,000,000**		
Gogebic	167	167	$63,000		1	
Iron	66	66	$605,000			
Ontonagon	200	200	$16,000		2	1
Houghton	44	43				
Keweenaw	160	158				
Baraga	118	117	$6,000			
.Marquette	154	153	$262,000			1
Dickinson	68	68	$20,000			
Menominee	71	71	$7,000			
Delta	94	94	$75,000			
Schoolcraft	19	19				
Alger	192	190	$11,000			
.Luce	119	118	$3,500			
Mackinac	58	57	$50,000			
Chippewa	98	98	$85,000			
15 Co Upp. Pen	**108 avg.**	**108 avg.**	**Total $1,203,500**		**3**	**2**
MICHIGAN TOTAL	**6,261**	**1,038**	**$20,798,500**	**$20,000,000**	**10**	**2**

Michigan had historically seen a major regional or statewide snowstorm approximately every 5 years. Local events are more frequent. Both may currently be increasing (and are projected to increase) due to climate change effects. Total casualties can be difficult to assess because many deaths are caused by automobile accidents, heart attacks from overexertion, and other secondary impacts that may be difficult to distinguish as weather-related. The NCDC data in the preceding table shows some clear geographic effects in historical snowstorm patterns. One is the lake effect—the table is organized so that "tiers" of counties are listed together, from south to north (and from west to east, within each tier). A dot appears just before the name of the westernmost county in each tier-group, and these counties, which are close to Lake Michigan, can also be seen to have greater snowfall events, and these numbers generally decline from county to county as one proceeds eastward across each tier. Within this 18-year historical average, these counties range from about 7 snowstorm days per year down to only about 2, but these averages show signs of increasing over time, due to increasing precipitation in Michigan. (However, the proportion of this precipitation that falls in the form of snow rather than rain or sleet is trickier to predict.) In parts of the Upper Peninsula, there is an average of up to 11 snowstorms per year.

By observing winter storm watches and warnings, adequate preparation can usually be made to reduce the impact of snowstorms on Michigan communities. Providing for the mass care and sheltering of residents left without heat or electricity, and mobilizing sufficient resources to clear blocked roads, are the primary challenges facing community officials. Severe snowstorms can affect every Michigan community. Therefore, every community should plan and prepare for severe snowstorm emergencies. That planning and preparedness effort should include the identification of mass care facilities and necessary resources such as cots, blankets, food supplies and generators, as well as snow clearance and removal equipment and services. Pre-planning for snow storage areas will be helpful. In addition, communities should develop debris management procedures (to include the identification of multiple debris storage, processing and disposal sites) so that the tree and other storm-related debris can be handled in the most expedient, efficient, and environmentally safe manner possible.

Heavy snows can shut down towns and cities for a period of a few days if snow is persistent and cannot be cleared in a timely fashion. Roof failures may occur as the weight and volume of snow cause damage to homes and buildings. Urban areas are especially susceptible to outages and problems with snow removal, while rural areas may have inaccessible roads for some time but have residents that are more prepared to handle power outages and temporary isolation. Motorists and passengers in cars can be stranded in rural areas and die of exposure because of inadequate preparation for conditions.

Impact on the Public

Snowstorms present hazards that are similar to ice storms, but occur much more frequently. Transportation impairments tend to be of longer duration and require the clearance of snowy "debris" out of the areas needed for transportation or other useful functions. The work required to move accumulated snow (which may "drift" to significant heights or be blown back in place by wintry winds) can often overwhelm the capacities of both individual residents as well as public workers and local budgets.

Impact on Public Confidence in State Governance

For this hazard, the main issues regarding public confidence in government predominantly involve: (1) the ability of the infrastructure of the impacted area to withstand the winter storm event and continue to serve area residents, and (2) the ability of the government(s) to efficiently clear away snow and ice from areas that are most vitally needed for transportation and other shared public uses (e.g. schools, hospitals). If any shortcomings or failures in one or both of these functions are too evident to citizens (or mass media providers), then the capacity, efficiency, and adequacy of government(s) may be called into question. In many areas, the State and different forms of local governments and agencies will have different types of responsibilities, and where problems arise in the coordination or clarity of these governments' actions and responsibilities, discontent can reasonably be expected to be expressed by citizens.

Impact on Responders

Responders are asked to be outdoors during winter weather events in which most citizens prefer to take shelter. In addition to the risks from winds, obscured vision, impaired control of vehicles, power failures and blocked roadways, winter storm events also expose responders to extremely cold temperatures for long periods of time, and may thus compound the difficulties, risks, and expenses of response. Fatigue can more easily become a problem under extreme

temperature conditions, either during winter weather emergencies or during extreme summer heat and humidity. Snow can impede facility access and make travel and outdoor activities treacherously slippery.

Impact on the Environment

Heavy snowstorms and severe blizzards can cause environmental impacts. Snowstorms can damage trees, with the weight of heavy snow accumulations bringing down limbs, branches, or entire trees. Dried dead trees more readily catch fire, contributing to wildfires in other seasons if not removed properly. Dead trees can become a breeding ground for beetles or other pests that can harm healthy green trees in non-winter seasons. Animal deaths can occur as a result of immobility, injury, infections, frost bite, hypothermia, etc. Floods often occur when snow melts, and can cause environmental effects (as described in the flooding section). Erosion from melted snow can occur, affecting beaches and soils, and harming vegetation.

Snow can function as a significant source of water pollution since it accumulates a variety of contaminants from the atmosphere and roadways. The removal of snow from roadways can damage the physical and biological environment with contaminants that include salts and salt additives, sediments, metals/emissions, asbestos, petroleum products, bacteria, organic chemicals, soil materials and litter. Those materials that accumulate in roadway-removed snow affect streams, rivers, ground water resources, and lakes, causing harm to fish species and destruction of bottom-dwelling fish fodder. The contamination of soil and groundwater can also result in vegetative stress and decreased productivity. The contamination in sediments can accumulate in the tissues of plants and animals and cause harm.

Climate Change Considerations

The effect of climate change upon Michigan is expected to cause an increase in the amount of precipitation. Even though the length of Michigan winters has been decreasing, the season remains an intense one. During the winter months, the increase in precipitation means that snowfall events will tend on average to be more intense. More snowfall is likely to happen at a time, and thus take the form of significant snowstorm events (e.g. 8 or more inches, higher snowdrifts, cancelled school sessions, etc.).

Michigan meteorologist Paul Gross notes that "contrary to what most would expect, the warming climate is causing an increase in snowfall in those winters where the storm track brings more frequent winter storms to the Great Lakes. In Detroit, for example, five of the ten all-time snowiest winters have occurred since 2004, two of the top-five highest combined snowfall in back-to-back winters have occurred since 2007, the all-time snowiest start of a season through the end of January occurred in 2013-2014 and, as of the date of this report, the winter of 2013-2014 was already in the top five for most consecutive days with at least one inch of snow on the ground."

Historically Significant Snowstorms of General Interest in Michigan and Across the United States

Winter 1888 - Northern U. S.

The fabled Winter of 1888 was devastating to much of the northern United States, with snow, freezing temperatures, and severe winds responsible for the deaths of hundreds of people and thousands of cattle across the Dakota Territory, Minnesota, Wisconsin, and Michigan's Upper Peninsula. As bad as conditions were in the Midwest, however, one single snowstorm will forever characterize that brutal winter. The famous Blizzard of 1888 struck the eastern seaboard on March 12, 1888, dumping 40-50 inches of snow in New York and creating 30-40 foot snowdrifts in parts of southern New England. Snowdrifts were reported over the tops of houses from New York to New England, including some three-story houses. One town in New York had a snowdrift that measured 52 feet in height. Over 400 people died in the blizzard, including 200 in New York City alone. Wind gusts up to 80 miles per hour were reported, which contributed greatly to the tremendous drifting and high number of deaths.

November 7-12, 1913 - Eastern Great Lakes (primarily Lake Huron)

Although severe winter storms on the Great Lakes are common in November, the fall storm of November 7-12, 1913 is considered the greatest ever to strike the Great Lakes. No other Great Lakes storm in modern history compares to the November 1913 storm in terms of death and destruction. The November 1913 storm development was similar to the monster storm that struck Michigan on January 26-27, 1978 (see previous description). Like the 1978 storm, the November 1913 storm was also dubbed a "white hurricane" because of its tremendous size and strength. Winds up to 62 miles per hour and blizzard-like snow struck Port Huron on November 8-9, while in Detroit wind gusts of 70 miles per hour were reported. Port Huron was buried with heavy snow and snow squalls, creating four to five-foot drifts that immobilized the city. The heavy snow pummeled many other shoreline communities as well. On Lake Huron, sailors reported continuous, battering waves at least 35 feet high. The constant barrage of water severely punished various ships and eventually led to their demise. Forty ships were believed to have sunk in that storm, with at least 235 sailors lost. Of the 40 vessels, eight were large lake freighters that went down with all aboard.

More Recent Major Snowstorms in Michigan

January 26-28, 1967 – Mid-Michigan

From January 26-28, 1967 a snowstorm dumped 24 inches of snow in Mid-Michigan, causing Lansing and other area communities to virtually come to a standstill. The storm contributed to 17 deaths across the region. Hundreds of motorists were stranded in their cars and had to be rescued by the National Guard and local law enforcement. The heavy snowfall caused the collapse of roofs on numerous homes and businesses, and shut down public transportation services. Several public shelters were opened to accommodate those stranded by the snow or without heat or electricity due to downed power lines.

January 26, 1977 – Southern Michigan

Beginning on January 26, 1977, a major snowstorm occurred that affected vast portions of southern Michigan. Winds of blizzard proportions resulted in extensive drifting of snow, blocking many roads. Many residents were isolated in rural residences or stranded in public shelters. This storm resulted in a Presidential Emergency Declaration for 15 counties in the southern part of the state.

January 26-27, 1978 – Statewide

On January 26-27, 1978 a severe snowstorm struck the Midwest, and Michigan was at the center of the storm. Dubbed a "white hurricane" by some meteorologists, the storm measured 2,000 miles by 800 miles and produced winds with the same strength as a small hurricane and tremendous amounts of snow. In Michigan, up to 34 inches of snow fell in some areas, and winds of 50-70 miles per hour piled the snow into huge drifts. At the height of the storm, it was estimated that over 50,000 miles of roadway were blocked, 104,000 vehicles were abandoned on the highways, 15,000 people were being cared for in mass care shelters, and over 390,000 homes were without electric power. In addition, 38 buildings suffered partial or total roof collapse. Two days after the storm, over 90% of the state's road system was still blocked with snow, 8,000 people were still being cared for in shelters, 70,000 vehicles were stranded, and 52,000 homes were still without electricity. This storm resulted in a Presidential Emergency Declaration for the entire state, to provide assistance with snow clearance and removal operations.

December 9-12, 1995 – Sault Ste. Marie (Chippewa County)

On December 9, 1995 a snowstorm moved across the Upper Peninsula and stalled near Sault Ste. Marie for nearly 24 hours, dumping a record 28 inches of snow on the city. That eclipsed the city's previous 24-hour snowfall record (15.2 inches, in 1988) by more than one foot. By the time the storm system passed on December 12, Sault Ste. Marie had received a total of 61.7 inches of snow. The excessive snowfall presented a great threat to public safety. Most city streets were impassable to emergency vehicles, and snowdrifts and piles restricted visibility at intersections and buried hundreds of fire hydrants. Schools and most businesses were closed due to the difficult conditions.

A Governor's Emergency Declaration was granted on December 13 to provide assistance with snow clearance and removal activities. The Michigan National Guard was activated, along with work crews from the Michigan Department of Transportation and the Michigan Department of Corrections, to clear and remove snow. (The Guard alone removed more than 150,000 cubic yards of snow in five days.) The Michigan Family Independence Agency and Michigan Office of Services to the Aging provided assistance to senior citizens and other homebound individuals. The Michigan Department of Environmental Quality waived regulations to allow the disposal of clean snow into the St. Mary's River. Other areas that received heavy snowfall in this storm event included Munising with 53 inches, Ontonagon with 43 inches, and Silver City and Houghton with 34 inches.

December 20, 1996 – Southwestern Lower Peninsula

On December 20, 1996 heavy snow rapidly became lake enhanced and dumped storm totals up to 20 inches in the southwestern Lower Peninsula. Schools were closed for up to two days in some areas. Some secondary roads were blocked until road crews could get control of the situation.

January 10-12, 1997 – Western Lower Peninsula

During a three day period from January 10- 12, 1997 heavy snow was reported in Ottawa and Kent County for all areas of snowfall of at least 12 inches or more. In neighboring Allegan County the snow was measured at 28 inches on Friday evening and 40 inches by Saturday afternoon. In the northern portion of the Lower Peninsula, Grand Traverse County received 12 to 18 inches. Schools were used as emergency shelters for stranded motorists throughout the affected area. Secondary roads across all of the area were blocked from Friday night into Saturday and interstates were also closed for a few hours late Friday into Saturday. Accidents occurred at the rate of 50 to 100 per county per day from the 10th through the 12th.

March 13-15, 1997 – Upper Peninsula

Beginning on the afternoon of March 13, 1997 and continuing until the morning of March 15, a snowstorm moved across the Upper Peninsula, dumping 20-30 inches of heavy snow in many communities. Although the Upper Peninsula is accustomed to heavy snows throughout the winter, this storm produced snowfall totals that were significant even for that region. In Marquette, nearly 33 inches of new snow fell. In a 24-hour period between March 13-14, Marquette received 28 inches of snow, breaking the 24-hour snowfall record set back in March 1986. The storm also produced a record snow depth of 63 inches at Marquette County Airport, eclipsing the previous record of 59 inches recorded in March 1976. The storm dropped 29 inches of snow at Phoenix in Keweenaw County, 25 inches at Herman in Baraga County, and 21 inches at Shingleton in Alger County. Numerous other communities across the region received between 16 and 20 inches of new snow.

October 26-27, 1997 – Southern Lower Michigan

An early season snowstorm crossed southern Lower Michigan on October 26, 1997, dumping 2-8 inches of heavy, wet snow. Because of the significant amount of foliage still left on the trees, the added weight of the heavy snow caused many trees and tree branches to break, resulting in numerous power outages and reports of property damage from downed trees. At the height of the storm, over 330,000 electrical customers statewide were left without power – 195,000 in the Grand Rapids area alone. Total property damage was estimated at $1.2 million. Because of the widespread power outages (some of which lasted 36-72 hours), shelters were established in several communities to care for senior citizens and others vulnerable to the cold. The storm forced the closure of many schools and businesses throughout the impacted area.

January 2-3, 1999 – Southern Lower Peninsula

In the early morning hours of January 2, 1999 a severe winter storm moved across the western and southern portions of Michigan. The storm grew in intensity and size, producing record or near-record snowfall that affected much of the southern two-thirds of the Lower Peninsula by the late evening hours of January 3. High winds and frigid temperatures created blizzard conditions that lasted until late in the day on January 4 in some areas. Subsequent storms over the next several days dumped an additional foot of snow in many areas of the state, resulting in snowfall of historic proportions in several Michigan communities. Combined, these winter storms produced the worst winter conditions to hit Michigan since the statewide blizzard that occurred in January 1978 (see description above).

The effects of the blizzard on the city of Detroit were the focus of national media attention. Detroit and surrounding communities received nearly two feet of snow during the blizzard. The unusually intense snowfall, coupled with the frigid temperatures and blowing and drifting snow, severely hampered snow removal operations within Detroit. The City's inability to plow residential streets created public health and safety concerns in many areas due to lack of access for police, fire, and other emergency vehicles. The unplowed streets and sidewalks also forced the Detroit school system to close for several days, idling more than 180,000 students. The heavy snowfall collapsed numerous commercial building roofs in Detroit and throughout southeast Michigan. In addition, ice dams on residential roofs were a widespread problem, damaging tens of thousands of structures. The record snowfall also hampered mail delivery, affected the ability of residents to travel to and from work, and negatively impacted business activity and tourism.

At Detroit Metropolitan Airport, the severe winter conditions forced the cancellation of hundreds of flights over the three-day period from January 2-4, stranding thousands of travelers without adequate accommodations. Numerous planes landed at the airport, only to sit on the runway apron for hours at a time – unable to unload passengers because the snow could not be cleared from the gates fast enough or there simply were not enough open gates or personnel to handle the large influx of planes. This situation also drew the attention of the national media and cast a negative shadow over the airline and airport operations. A Presidential Emergency Declaration was granted for the 31 Michigan counties that received record or near-record snowfall, making available Federal snow removal assistance under the Federal Emergency Management Agency's (FEMA) Public Assistance Grant Program.

January 12-14, 1999 – Southeastern Lower Peninsula

Large snowfall amounts caused difficulty in finding places to store the snow. Roofs collapsed under the weight of the snow and especially caused expensive damage to a shopping center and numerous businesses across the metropolitan area. Ice dams caused many leaking roofs (estimated in the tens of thousands),

including damage to rare documents in the Clements Library of the University of Michigan in Ann Arbor. Estimated direct property damage amounted to $950,000 in Wayne County and $350,000 in Oakland County (plus three injuries), but these figures obviously do not include the problems from all the ice dams on roofs.

November 20, 2000 – Southwestern Lower Peninsula

On November 20, 2000 the first snow storm of the season for the Grand Rapids area produced a record 24 hour snowfall of 11.5 inches at the National Weather Service in Grand Rapids, breaking the old record of 10.4 inches. Lake effect snow continued through the night and during the morning hours of the 21st, and 1 to 2 feet of snow fell across parts of Ottawa County. Allegan County also received 24 inches.

December 11-31, 2000 – Central and Southern Lower Peninsula

In the early morning hours of December 11, 2000 a severe winter storm moved through the state, inflicting its heaviest effects on the southern two-thirds of the Lower Peninsula before moving out of the state on the morning of December 12. That storm produced record or near-record 24-hour snowfall levels in 31 counties, paralyzing the entire region. High winds and frigid temperatures created blizzard conditions that lasted until late in the day on December 13 in some areas. The storm produced great hardships for many Michigan communities. Schools across much of southern Lower Michigan were closed for several days, the storm forced the cancellation of hundreds of airline flights in and out of Detroit Metro Airport and at other airports across the region, and many businesses were forced to close at the height of the Christmas shopping season (the most profitable shopping period of the year). Damage in Genesee County was estimated at $1.1 million, as the roof of a manufacturing company collapsed and injured one person. During the storm, up to 200 cars were stranded on I-75 south of Flint. A Richmond home burned down because firefighter vehicles were unable to reach it. Around Caro (Tuscola County), 41 automobile accidents took place, including an 18-car pile-up that required snowmobiles to respond to. 16.3" of snow had fallen around Caro.

Another series of winter storms the following week dumped an additional foot or more of snow across southern Lower Michigan, increasing snow depths in many counties to two feet or more. The tremendous snow depths caused a host of public health and safety concerns across the region. The snow fell at such a steady rate in many areas that public works crews worked at maximum capacity – often around the clock – for two weeks just to keep pace. The weight of the accumulated snow caused numerous collapsed roofs on homes and businesses, and ice dams and water seepage damaged thousands of structures well into January 2001. In addition, several house fires erupted when water from melting snow and ice seeped into electric meter boxes.

The cumulative effects of the heavy snowfall, high winds, and severe cold temperatures that began on December 11 caused problems across the region for the next several weeks. The sheer volume of snow made it difficult to handle, and the process of clearing it out of the way became difficult and expensive, as there was almost no place to put it. Many communities used the majority of their annual snow-removal budget and their road salt supply to combat these storms. The winter storms of December 2000 produced the worst winter conditions to hit Michigan since the statewide blizzards that occurred in January 1978 and January 1999. In Flint and Saginaw, the December 2000 snowfall set an all-time record for ANY month. In many other areas, it set all-time records for the month of December.

A Presidential Emergency Declaration was granted for the 39 Michigan counties that received record or near-record snowfall or incurred significant cumulative effects, making available Federal snow removal assistance under the Federal Emergency Management Agency's (FEMA) Public Assistance Grant Program.

January 5, 2001 – Livingston and Oakland Counties

Three persons were injured in Brighton when the weight of accumulated snow caused an awning-style roof to collapse along the edge of a warehouse ($75,000 damage). Later in the day, a man died in Waterford Township by falling from his roof while trying to shovel snow from it.

December 23-29, 2001 – Southwestern and Northern Lower Peninsula

From December 23-29, 2001, Grandville (in Kent County) received 26 inches of snow. Up to 15 inches of snow fell in Grandville in less than 24 hours and around 24 to 26 inches of snow fell total in a band from Ottawa County southwest to Allegan County. Even more lake effect snow redeveloped on the 28th and continued through the 29th, producing additional snowfall of 8 to as much as 22 inches across the area. 12 to 18 inches of snow was common across the Grand Rapids area. There was also a narrow strip of around a foot of snow that fell about 25 miles inland from Ottawa county.

Storm total snowfalls broke all previous records for snowfall in one week in several locations across southwest Michigan. Grandville (Kent County) ended up with 70.2 inches of snow for the week, which was the greatest reported snowfall total across the area. The National Weather Service Forecast Office in Grand Rapids (Kent County) had a storm total snowfall of 50.6 inches for the week. Generally speaking, the heaviest snow accumulations for the week occurred along the US-131 corridor from Grand Rapids down through Allegan County, where two to four feet of snow fell. The cities of Petoskey and Charlevoix broke their 2 and 3 day snowfall total records with amounts of 44 and 60 inches and 27 and 39 inches, respectively. Traverse City tied their 2 day snowfall record with 20.5 inches from the 28th through the 29th. Many other areas saw snowfall totals of a foot or more during the last week of December.

January 29-30, 2002 – Southern Lower Michigan

Severe winter weather battered much of the Lower Peninsula for two days during the end of January 2002, bringing a foot or more of snow, mixed with sleet and ice. Schools were closed, roads were flooded, and over 152,000 were left without power. Four people were killed in weather-related traffic accidents in Kent, Saginaw, Midland, and St. Joseph Counties. AAA Michigan served more than 2,850 motorists by the late afternoon on January 30. Detroit Metropolitan Airport cancelled more than 170 departures and 183 arrivals due to weather conditions.

March 2, 2002 – Lower Michigan Peninsula

On March 2, 2002 a winter storm produced heavy snow across most of the Lower Peninsula, producing 12 to 18 inches of snow. The maximum snowfall reported was in Ludington (Mason County), where 18 inches of snow fell. The snow was particularly wet and heavy, and numerous tree limbs and power lines were downed in the area.

February 7 and 12, 2003 – Southwestern Lower Michigan

On February 7, 2003, blizzard conditions caused a 72-car accident on I-94 in Benton Township (Berrien County). The accident began when a car slid under the back of a semi-tractor trailer during whiteout conditions. Those involved in the crash stated that the heavy lake-effect snow had reduced visibility and caused poor road conditions. When the motorists approached the I-94 and I-196 interchange, the weather changed from bad to worse, causing zero visibility. These conditions caused cars to slow at different rates, and thus a chain collision ensued.

Only five days later, on February 12, 2003 an Alberta clipper moved through and produced heavy snow across western Lower Michigan. The heaviest snowfall report was received from Walker (Kent County), where 14 inches of snow fell. A large swath of anywhere from 6 to 10 inches of snow fell across other parts of Ottawa County as well as Kent County. There were also localized reports of a foot or more of snow received in the two counties.

January 19-20, 2004 – Northwestern Lower Peninsula

Heavy lake effect snow came in off of Lake Michigan, accompanied by gusty northwest winds and blowing and drifting. The most persistent band of snow settled in from central Leelanau County to western Grand Traverse County. Around 20 inches of snow fell near Interlochen, with drifts of 5 to 6 feet across M-72 in Leelanau County.

January 27, 2004 – Central Lower Michigan

On January 27, 2004, six to ten inches of snowfall occurred across much of central Lower Michigan. Up to 14 inches of snow accumulated northeast of Grand Rapids, in Montcalm County. Visibility was near zero when a pileup involving about 50 cars and trucks occurred on I-96 near Portland, shutting down both sides of the highway. There was only one injury reported and the highway was reopened about three hours later. Police in the tri-county area had responded to more than 200 accidents during the day.

November 24-25, 2005 – Northern Lower Peninsula

Lake effect snow quickly developed and became intense by the afternoon of Thanksgiving Day throughout much of the northern portions of the Lower Peninsula. Near-blizzard conditions developed, with wind gusts of 25 to 35 mph inland and 50 mph near the coastlines, lowering visibilities to near zero at times. Total snowfall amounts of 12 to 18 inches were common in the prime snow belts regions around Gaylord, Kalkaska, and Mancelona. Holiday travel was impacted severely by the falling, blowing, and drifting snow. Numerous accidents occurred on area highways.

February 3-4, 2007 – Southwest Lower Michigan

The combination of lake-effect snow (and snow already on the ground) with very strong winds resulted in blizzard conditions across western Lower Michigan on February 3rd. The maximum snowfall total for a twelve hour period was eight inches, and the maximum snowfall total for a 24-hour period was 12 inches. The highest snowfall total for the entire event was 17 inches, in Grandville. The Gerald R. Ford International Airport in Grand Rapids reported visibility at or under a quarter-mile from 9:30 a.m. through 8 p.m. on Saturday February 3rd. Numerous other observation sites across far western Lower Michigan also reported blizzard conditions. Many locations reported sustained winds of 20 to 30 mph, with gusts to around 40 mph, during the late morning and afternoon hours of the 3rd. The blizzard conditions resulted in numerous road closures, power outages, and car accidents.

February 25-26, 2007 – Northern Lower Peninsula

A low pressure system stalled out over the Southwest Great Lakes region resulting in a fairly extensive period of accumulating snowfall and gusty east winds in much of Northern Lower Michigan. The axis of heaviest snowfall stretched from Cadillac to Lake Ann, with total of 12 to 15 inches. Blustery winds produced considerable blowing and drifting snow. Wexford County officials reported that more than 50 vehicles slid off of area roads. Numerous schools were closed on the 26th.

February 6-7, 2008 – Saginaw County

Widespread heavy snowfall of 8 to 12 inches occurred along and north of the I-69 corridor in eastern Michigan. The heaviest snow total of 16 to 18 inches occurred in Saginaw County. This snowstorm total in Saginaw County was the biggest amount since the Blizzard of 1978. Strong northeast winds off of Saginaw Bay also led to near blizzard conditions. Road crews in Saginaw County could not keep up with the snow, which fell at a rate of 2-4 inches per hour. Two to three foot snow drifts left at least 50 cars stranded. Snowfall amounts tapered off south of I-69, as sleet mixed in, cutting down accumulations quickly, with less than 3 inches across Wayne County and points to its south.

February 10, 2008 – Southwest Michigan

A blizzard event involved a combination of extreme cold, frequent wind gusts up to 40 mph, whiteout conditions, heavy snow, and blowing snow. There was a fifty-car pileup on I-196 in Ottawa County, causing 20 persons to receive treatment for minor injuries. Snowfall totals were the greatest over Allegan and Van Buren Counties. Snow drifts of 3 to 5 feet deep were common in rural areas. Property damage was estimated at $250,000 in Ottawa County.

December 21-22, 2008 – Western Lower Peninsula

From December 21-22, 2008 six to 12 inches of snow fell in Kent and Ottawa Counties, accompanied by wind gusts up to 45 mph. This resulted in two to three foot snow drifts across portions of the area. In conjunction with the blizzard to near-blizzard conditions, this produced dangerous travel conditions. Farther north, Wellston ended up with 23 inches of snow in 24 hours, and many Northern Lower Peninsula areas received similar amounts. At the height of the storm, several stretches of highway were shut down due to multiple vehicle accidents.

December 3-4, 2009 – Grand Rapids Area

From December 3-4, 2009 over a foot of snow was reported across portions of Ottawa County, where 15 inches fell in Marne and 14 inches fell in Coopersville. Several inches of slushy snow accumulated on roads from Muskegon to Grand Rapids. The following week, four to eight more inches of snow, in conjunction with wind gusts to 40 mph, created near-blizzard conditions at times, resulting in very hazardous travel conditions. Numerous accidents were reported, due to slippery roads and reduced visibility in the blowing snow.

December 9-11, 2009 – Northern Lower Peninsula

From December 9-11, 2009 heavy snowfall totals and blizzard conditions were common across all of Northern Michigan. The snow transitioned to lake effect snow that night, and lasted into the 11th in some of the snow belts. Gaylord had its 2nd largest three-day snowfall since 1950, with 21.8 inches. There was a considerable amount of wind, with some gusts over 50 mph, causing blowing and drifting snow. Almost all school districts were closed on the 9th, and some schools called off classes for three consecutive days. Numerous accidents were reported, due to slippery roads and reduced visibility in the blowing snow.

February 9-10, 2010 – Ottawa County

From February 9-10, 2010 six to ten inches of snow fell across Ottawa County. The storm coincided with Michigan's winter "Count Day," used to determine base funding for local public school systems. Many school systems closed due to the snowstorm. Several significant accidents occurred on the region's primary arteries. I-94 was closed for several hours, due to jackknifed trucks. There was also a multiple vehicle pileup on I-196.

February 1-2, 2011 – Southern Lower Peninsula

From February 1-2, 2011 a major winter storm occurred throughout much of Lower Michigan. The storm brought 10 to 15 inches of snow and blizzard conditions to much of southern Lower Michigan. Wind gusts in excess of 40 mph combined with heavy snow to produce whiteout conditions and snowdrifts of 3 to 5 feet. Thunder accompanied the snow in some areas with snowfall rates exceeding two inches per hour. Many businesses, schools (including major universities), and some government offices were closed the next day. Most main roads were plowed by the next day but some side streets were not cleared for a couple more days.

November 29-30, 2011 – Central Southern Lower Peninsula

A snowstorm dumped 8 to 10 inches of snow across multiple counties in central Michigan. The heavy wet snow, plus strong winds, caused many trees, limbs, and power lines to fall, leaving 30,000 persons without power. Numerous traffic accidents occurred, and a gas station awning collapsed in Haslett (Ingham County) under the weight of the snow. Property damages totaled $1 million in each of the following counties: Jackson, Calhoun, Ingham, Eaton, and Clinton. In Eaton County, two fallen trees partially blocked Billwood Highway in Windsor Township.

March 2-3, 2012 – Northern Lower Peninsula (Leelanau, Benzie, and Grand Traverse Counties)

A high-impact snowstorm brought snowfall totals that ranged from 6 to 14 inches across most of Northern Michigan, with higher amounts in some areas and a maximum of 20 inches near Lake Ann (Benzie County). The snow was very wet and heavy, causing many trees and power lines to fall. Power outages were widespread, and the majority of Northern Michigan residents lost power at some point during or after the storm, sometimes for as long as a week. In Benzie County, 95% of residents lost power, property damages totaled $600,000, and crop damages totaled $2 million. In Grand Traverse County, $600,000 in property damage was done, along with $5 million in crop damage. Substantial damage was done to fruit trees, especially cherry trees. In Leelanau County, $650,000 in property damage and $13 million in crop damage was reported. Many communities opened shelters, to aid those whose homes had no power or heat.

Winter of early 2014 – Michigan

Although the winter events are still occurring at the time of this writing, and therefore are too new to summarize, it is clear that the winter has been an unusually challenging one. Roadway sections across the state were left in poor condition by the effects of a series of thaws and re-freezes during early winter. In addition to below-average temperatures (see the extreme temperatures section), an above-average amount of snowfall gave many Michigan communities trouble in clearing roadways and finding places to store the snow. The heavy snows followed a damaging ice storm that left many households without power. Hundreds of traffic accidents took place during icy and blizzard conditions. The next edition of the Michigan Hazard Analysis will contain a full summary of the season's events.

Programs and Initiatives

Note: Many of the programs and initiatives designed to mitigate, prepare for, respond to, and recover from ice and sleet storms have the dual purpose of also protecting against snowstorms. As a result, there is some overlap in the narrative programs and initiatives descriptions for each respective hazard. This redundancy allows each hazard section to stand alone, eliminating the need to refer to other hazard sections for basic information.

National Weather Service Doppler Radar

The National Weather Service has completed a major modernization program designed to improve the quality and reliability of weather forecasting. The keystone of this improvement is Doppler Weather Surveillance Radar, which can more easily detect severe weather events that threaten life and property – including severe winter weather events such as snowstorms. Most importantly, the lead time and specificity of warnings for severe weather have improved significantly.

National Weather Service Watches, Warnings and Advisories

The National Weather Service issues winter storm watches and winter weather warnings to notify the public of severe winter weather conditions. A winter storm watch indicates that severe winter weather conditions (freezing rain, sleet, or heavy snow) may affect an area, while a winter weather warning indicates that severe winter weather conditions are imminent.

Winter storm warnings can be issued for snow alone, but they can also take on different varieties. For example, a blizzard warning signifies that blizzard conditions are imminent or occurring. Blizzard conditions mean that the visibility will frequently be one-quarter mile or less in falling or blowing snow, with wind speeds of at least 35 miles per hour. A wind chill warning is issued when wind chills drop below -30 degrees Fahrenheit, with winds equal to or greater than 10 miles per hour. Finally, an ice storm warning is issued for a significant accumulation of ice, normally a coating of at least one-quarter inch.

The National Weather Service also issues a number of different advisories for winter weather. These advisories can be issued for snow, freezing rain, blowing snow, and wind chill, among other things. Advisories mean that conditions are expected to cause significant inconveniences and may be hazardous. However, if caution is exercised, the situation should not become life threatening.

The State and local government agencies are warned via the Law Enforcement Information Network (LEIN), National Oceanic and Atmospheric Administration (NOAA) weather radio, and the Emergency Managers Weather Information Network (EMWIN). Public warning is provided through the Emergency Alert System (EAS). The National Weather Service stations in Michigan transmit information directly to radio and television stations, which in turn pass the warning on to the public. The National Weather Service also provides detailed warning information on the Internet, through the Interactive Weather Information Network (IWIN).

Winter Hazards Awareness Week

Each fall, the Emergency Management and Homeland Security Division, Department of State Police, in conjunction with the Michigan Committee for Severe Weather Awareness, sponsors Winter Hazards Awareness Week. This annual public information and education campaign focuses on winter weather hazard events such as snowstorms, blizzards, extreme cold, and ice and sleet storms. Informational materials on winter weather hazards and safety are disseminated to schools, hospitals, nursing homes, other interested community groups and facilities, and the general public.

Electrical Infrastructure Reliability

One of the major problems associated with any winter weather hazard (including snowstorms) is the loss of electric power. Although the problem is not quite as chronic in Michigan as it is with ice storms, snowstorms have nonetheless caused several widespread and severe electrical power outages. Weather-related damage to electric power facilities and systems is a concern that is being actively addressed by utility companies across the state. Detroit Edison, Consumers Energy and other major electric utility companies have active, ongoing programs to improve system reliability and protect facilities from damage by snow, ice, severe winds, and other hazards. Typically, these programs focus on trimming trees to prevent encroachment of overhead lines, strengthening vulnerable system components, protecting equipment from lightning strikes, and placing new distribution lines underground. The Michigan Public

Service Commission (MPSC) monitors power system reliability to help minimize the scope and duration of power outages.

Urban Forestry/Tree Maintenance Programs

Urban forestry programs can be very effective in minimizing snowstorm damage caused by falling trees or tree branches. In almost every severe snowstorm, falling trees and branches cause power outages and clog public roadways with debris. However, a properly designed, managed and implemented urban forestry program can help keep tree-related damage and impact to a minimum. To be most effective, an urban forestry program should address tree maintenance in a comprehensive manner, from proper tree selection, to proper placement, to proper tree trimming and long-term care.

Every power company in Michigan has a tree trimming program, and numerous local communities have some type of tree maintenance program. The electrical utility tree trimming programs are aimed at preventing encroachment of trees and tree limbs within power line rights-of-way. Typically, professional tree management companies and utility work crews perform the trimming operations. At the local government level, only a handful of Michigan communities have actual urban forestry departments or agencies. Rather, crews from the public works agency or county road commission perform the bulk of the tree trimming work.

When proper pruning methods are employed, and when the work is done on a regular basis with the aim of reducing potential storm-related damage, these programs can be quite effective. Often, however, tree trimming work is deferred when budgets get tight or other work is deemed a higher priority. When that occurs, the problem usually manifests itself in greater storm-related tree debris management problems down the line.

Hazard Mitigation Alternatives for Snowstorms

- Increased coverage and use of NOAA Weather Radio.
- Tree trimming and maintenance to prevent limb breakage and safeguard nearby utility lines. (Ideal: Establishment of a community forestry program with a main goal of creating and maintaining a disaster-resistant landscape in public rights-of-way.)
- Buried/protected power and utility lines. (NOTE: Where appropriate. Burial may cause additional problems and costs in case of breakage, due to the increased difficulty in locating and repairing the problem.)
- Establishing heating centers/shelters for vulnerable populations.
- Proper building/site design and code enforcement relating to snow loads, roof slope, snow removal and storage, etc.
- Agricultural activities to reduce impacts on crops and livestock.
- Pre-arranging for shelters for stranded motorists/travelers, and others.
- Using snow fences or "living snow fences" (rows of trees or vegetation) to limit blowing and drifting of snow over critical roadway segments.

Tie-in with Local Hazard Mitigation Planning

Because many means of implementing mitigation actions occur through local activities, this updated MHMP places additional emphasis on the coordination of State-level planning and initiatives with those taking place at the local level. This takes two forms:

1. The provision of guidance, encouragement, and incentives to local governments by the State, to promote local plan development, and
2. The consideration of information contained in local hazard mitigation plans when developing State plans and mitigation priorities.

Regarding the first type of State-local planning coordination, MSP guidance has included the “Local Hazard Mitigation Planning Workbook” (EMD-PUB 207), which is currently being updated for release by 2015. For the second type of State-local planning coordination, a section later in this plan summarizes hazard priority information as it has been reported in local hazard mitigation plans. Here, it will merely be noted that snowstorms were identified as one of the most significant hazards in local hazard mitigation plans for the following counties: Counties Reporting Snowstorms as one of their top hazards: Alger, Allegan, Alpena, Antrim, Baraga, Barry, Benzie, Berrien, Branch, Calhoun, Cass, Charlevoix, Cheboygan, Chippewa, Clinton, Delta, Emmet, Genesee, Gogebic, Grand Traverse,

Gratiot, Hillsdale, Huron, Isabella, Jackson, Kalamazoo, Kalkaska, Kent, Keweenaw, Lake, Lapeer, Leelanau, Lenawee, Macomb, Manistee, Marquette, Mason, Menominee, Midland, Missaukee, Monroe, Montmorency, Muskegon, Newaygo, Oceana, Ogemaw, Oscoda, Otsego, Ottawa, Roscommon, Saginaw, Schoolcraft, Shiawassee, Tuscola, Van Buren, Wexford. (56 counties).

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Severe Winds

Non-tornadic winds of 58 miles per hour or greater.

Hazard Description

Severe winds, or straight-line winds, sometimes occur during severe thunderstorms and other weather systems, and can be very damaging to communities. Often, when straight-line winds occur, the presence of the forceful winds, with velocities over 58 mph, may be confused with a tornado occurrence. Severe winds have the potential to cause loss of life from breaking and falling trees, property damage, and flying debris, but tend not to cause as many deaths as tornadoes do. However, the property damage from straight line winds can be more widespread than a tornado, usually affecting multiple counties at a time. In addition to property damage to buildings (especially less sturdy structures such as storage sheds, outbuildings, etc.), there is a risk for infrastructure damage from downed power lines due to falling limbs and trees. Large scale power failures, with hundreds of thousands of customers affected, are common during straight-line wind events.

Hazard Analysis

Another dangerous aspect of straight line winds is that they occur more frequently beyond the April to September time frame than is seen with the other thunderstorm hazards. It is not rare to see severe winds ravage parts of the state in October and November—some winter storm events in Michigan have produced wind-speeds of 60 and 70 miles per hour. Stark temperature contrasts seen in colliding air masses along swift-moving cold fronts can occur during practically any month.

Figures from the National Weather Service indicate that severe winds occur more frequently in the southern-half of the Lower Peninsula than any other area of the state. On average, severe wind events can be expected 2-3 times per year in the Upper Peninsula, 3-4 times per year in the northern Lower Peninsula, and 5-7 times per year in the southern Lower Peninsula. It must be emphasized that this refers to winds from thunderstorms and other forms of severe weather, but **not** tornadoes.

Severe winds spawned by thunderstorms or other storm events have had devastating effects on Michigan, resulting in 122 deaths, nearly 700 injuries, and hundreds of millions of dollars in damage to public and private property and agricultural crops since 1970. Severe wind events are characterized by wind velocities of 58 miles per hour or greater, with gusts sometimes exceeding 74 miles per hour (hurricane velocity), but do not include tornadoes. (Please refer to the Tornadoes section which follows, for more information on that hazard.)

Another dangerous aspect of straight line winds is that they occur more frequently beyond the April to September time frame than is seen with the other thunderstorm hazards. It is not rare to see severe winds ravage parts of the state in October and November. Stark temperature contrasts seen in colliding air masses along swift-moving cold fronts occur regularly during those months.

National Weather Service forecasts of severe winds usually give sufficient warning time to allow residents to take appropriate action to reduce, at least to some degree, the effects of wind on structures and property. Little can be done to prevent damage from flying objects. However, proper structural bracing techniques can help minimize or even eliminate major damage due to the loss of a roof or movement of a building off its foundation.

In terms of response to a severe wind event, providing for the mass care and sheltering of residents left without heat or electricity, and mobilizing sufficient resources to clear and dispose of downed tree limbs and other debris from roadways, are the primary challenges facing Michigan communities. In addition, downed power lines present a public safety threat that requires close coordination of response efforts between local agencies and utility companies. Thunderstorms and severe winds can affect every Michigan community. Therefore, every community should adequately plan and prepare for this type of emergency. That planning and preparedness effort should include the identification of necessary resources such as cots, blankets, food supplies, generators, and debris removal equipment and services. In addition, each community should develop debris management procedures (to include the identification of multiple debris storage, processing and disposal sites) so that the stream of tree and construction debris can be handled in the most expedient, efficient, and environmentally safe manner possible.

To mitigate the effects of severe winds, communities can: 1) institute a comprehensive urban forestry program, 2) properly brace and strengthen vulnerable public facilities, 3) ensure compliance with manufactured home anchoring regulations, 4) coordinate with utility companies on local restoration priorities and procedures, 5) improve local warning systems, and 6) amend local codes to require structural bracing, where appropriate, in all new residential and commercial construction.

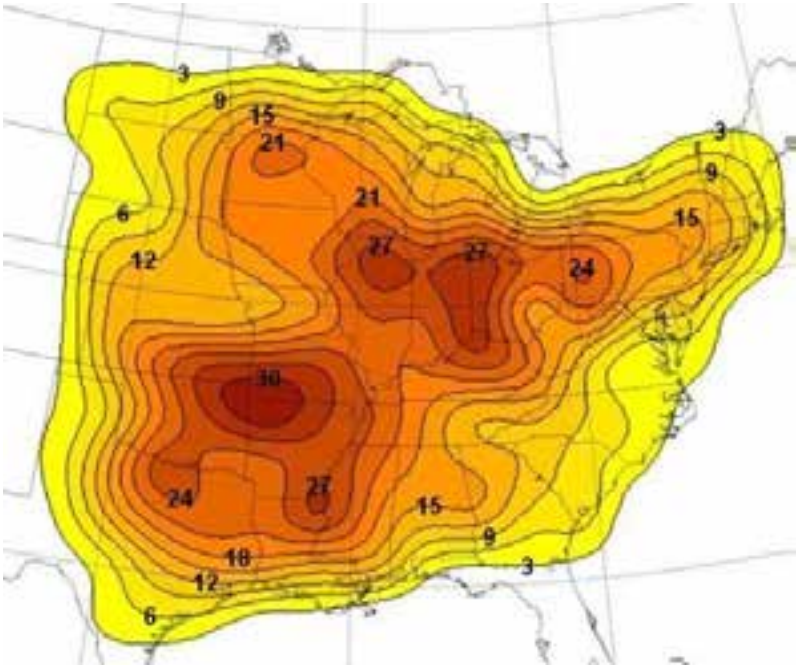
Derecho

A Derecho, also called a bow echo, is a widespread and long-lived windstorm that is associated with a fast-moving band of severe thunderstorms. "Bow echo" describes the curved weather front that typefies a derecho, but the word "derecho" comes from the Spanish language and means "direct." By contrast, tornado winds "turn" (the Spanish word *tornar* meaning "to turn"). The word derecho provides a conveniently brief term to describe severe non-tornadic winds. By a "widespread event" the definition means that the front can be hundreds of miles long and more than 100 miles across. The damage path of a derecho will be at least 250 miles long. Derechos are usually not associated with a cold front, but instead with a stationary front. They occur mostly in July, but can occur at any time during the spring or summer. The following map gives an indication of the pattern of Derecho frequency across the Midwest.

There are three types of Derechos:

- Serial Derecho - Multiple bow echoes embedded in a massive line typically around 250 miles long. This type of Derecho is usually associated with a very deep low pressure system. Also because of embedded supercells, tornadoes can easily spin out of these types of Derechos.
- Progressive Derecho - A small line of thunderstorms take a bow-shape and can travel for hundreds of miles.
- Hybrid Derecho - Has characteristics of a serial and progressive Derecho. These types of Derechos are associated with a deep low pressure system like serial Derechos, but are relatively small in size like progressive Derechos.

Moderate and High Intensity Derechos
1980-2001



Note: Numbers on map indicate the number of Derechos that occurred during the period.
Source: National Oceanic and Atmospheric Administration

As the following table shows, severe wind events average about 3 events per year in Upper Peninsula counties, 2 per year in northern Lower Peninsula counties, and 10 to 17 times per year in southern Lower Peninsula counties.

Severe Wind History for Michigan Counties – arranged by region – Jan. 1996 to Oct. 2013
(The Lower Peninsula regions are ordered by "tiers" from south to north, west to east)
Please refer to the Michigan Profile Map section for an explanation of regional divisions

COUNTY or area	Severe Wind Events	Days with Severe Winds	Tot. property damage	Tot. crop damage	Injuries	Deaths
Washtenaw	300	151	$13,335,000		2	1
Wayne	306	155	$64,495,000		28	8
.Livingston	219	117	$3,319,500		1	
Oakland	414	163	$16,319,000		8	2
Macomb	279	133	$22,953,000		2	
5 Co Metro region	**304 avg.**	**144 avg.**	**$120,421,500**		**41**	**11**
Berrien	178	116	$866,000	$120,000	8	2
Cass	137	101	$1,223,000		5	
St. Joseph	145	97	$648,750			2
Branch	162	94	$422,500			
Hillsdale	150	90	$562,500		2	
Lenawee	216	113	$7,254,000		5	
Monroe	198	124	$5,030,000		8	
.Van Buren	114	83	$1,511,000	$40,000		1
Kalamazoo	124	95	$5,808,000	$145,000		1
Calhoun	156	110	$29,270,000	$235,000	10	1
Jackson	118	84	$1,210,000	$30,000		
.Allegan	246	153	$2,991,000	$125,000	3	
Barry	201	126	$2,502,000	$85,000		
Eaton	196	116	$5,255,000	$210,000		
Ingham	210	116	$6,060,000	$85,000		
.Ottawa	209	133	$38,957,000	$10,090,000	21	4
Kent	227	139	$63,509,000	$20,115,000	60	3
Ionia	184	116	$2,411,000	$75,000	2	
Clinton	196	118	$3,077,000	$100,000		2
Shiawassee	230	144	$5,025,000	$30,000		
Genesee	384	178	$9,942,000	$30,000	3	
Lapeer	277	162	$5,466,000	$30,000	1	
St. Clair	286	164	$6,654,000	$30,000		
.Muskegon	191	117	$29,471,250	$5,050,000	5	1
Montcalm	183	123	$16,354,000	$100,000	23	
Gratiot	162	106	$2,478,000	$45,000		
Saginaw	292	158	$7,905,000	$30,000	5	
Tuscola	145	91	$3,290,950			
Sanilac	92	65	$2,729,500	$4,000	1	
.Mecosta	40	33	$626,110	$10,000		
Isabella	54	47	$1,265,000	$15,000		
Midland	88	71	$2,828,000			
Bay	105	72	$4,986,000			1
Huron	118	76	$3,091,000			1
34 Co S Lower Pen	**177 avg.**	**110 avg.**	**$280,679,560**	**$36,829,000**	**162**	**19**

Continued on next page…

Part 2 of Michigan County Wind History Table

.Oceana	38	32	$4,607,000	$50,000	37	
Newaygo	51	39	$2,118,000	$40,000		2
.Mason	48	39	$1,677,000	$15,000	5	
Lake	31	30	$2,144,000			
Osceola	32	30	$564,500	$25,000	1	
Clare	41	34	$519,500	$15,000	1	
Gladwin	31	26	$256,500			
Arenac	28	23	$222,500		4	
.Manistee	45	36	$538,500			
Wexford	36	29	$194,000			
Missaukee	20	17	$301,000			
Roscommon	51	40	$233,000		1	
Ogemaw	51	41	$450,530		1	
Iosco	36	27	$151,000			
.Benzie	24	20	$158,000			
Grand Traverse	38	29	$300,500	$1,000		
Kalkaska	28	22	$63,000			
Crawford	28	21	$252,000			
Oscoda	27	24	$168,000		1	
Alcona	42	35	$93,000		1	
.Leelanau	33	26	$123,000	$8,000		
Antrim	55	41	$231,000		1	
Otsego	38	35	$180,500			
Montmorency	38	31	$235,000	$5,000	1	
Alpena	40	34	$190,000			
.Charlevoix	35	30	$273,000			
Emmet	35	31	$281,000		1	
Cheboygan	30	27	$81,000	$100,000		
Presque Isle	26	23	$80,000			
29 Co Northrn Lower Pen	**36 avg.**	**31 avg.**	**$16,686,030**	**$259,000**	**55**	**2**
Gogebic	83	56	$171,500	$1,000,000		1
Iron	55	40	$70,500	$2,000,000		
Ontonagon	59	42	$57,000	$1,060,000		
Houghton	64	37	$138,500	$1,000,000		
Keweenaw	38	35	$341,000			
Baraga	49	33	$463,500			
.Marquette	119	69	$619,750			2
Dickinson	60	42	$878,000			
Menominee	64	46	$124,500			
Delta	68	39	$986,200	$4,250,000	2	
Schoolcraft	35	31	$675,000	$2,613,000		
Alger	45	38	$251,000	$1,001,000	1	
.Luce	36	24	$171,000	$1,000		
Mackinac	24	21	$89,000			
Chippewa	31	26	$75,500			
15 Co Upp.Pen	**55 avg.**	**39 avg.**	**$5,111,950**	**$12,925,000**	**3**	**3**
MICHIGAN TOTAL	**7,324**	**780**	**$403,452,030**	**$49,397,000**	**261**	**34**

Impact on the Public

Severe winds tend to impede transportation, causing slowed traffic and impaired control on roadways, and delays in the flight schedules for airlines. In addition, their physical impact can be comparable to that of a weak tornado, judged in terms of the severity of the resulting property damage, but with a more widespread area of effect. Structural collapse, and damages caused by falling trees/limbs, can cause injury and impairment of the residential and commercial use of the affected properties. It is very common for winds to cause trees and their limbs to break communication and power lines, causing the types of impacts described for the lightning hazard (and in the section on infrastructure failures).

Impact on Public Confidence in State Governance

When winds cause infrastructure failures, a question may be raised about the adequacy of that infrastructure, its maintenance, and its design and regulation. In events that require mass sheltering, such as schools or large gatherings (e.g. a county fair or community-sponsored event), the ability of local and state government to adequately plan for severe weather is often vital to the success of such events, which themselves are often important for various sectors of the local and state economy. Citizen discontent and media-exacerbated controversies have arisen from situations in which inadequate planning was evident, or provisions for public sheltering were inadequate.

Impact on Responders

Responders tend to be working outdoors in conditions from which most residents are taking shelter. Although special training and safety precautions have usually been taken (e.g. for line-repair workers), nevertheless, responders are more exposed to and at-risk from the impacts of severe winds. Some winds, such as the most extreme gusts from severe straight-line winds (microbursts), can be brief, but can still be surprising and harmful to those caught in them. Strong winds can also persist for many hours and exacerbate the existing difficulties and challenges involved in emergency response—impeding traffic, causing power loss and road closures, and making the use of equipment more difficult.

Impact on the Environment

Non-tornadic winds of at least 58 mph are classified as severe winds and/or derechos. Some of the harmful effects of wind on the environment include full-grown trees being completely uprooted and knocked down, or large acreage of forest land being destroyed. Large amounts of debris, elements from collapsed structures, and destroyed natural vegetation can result from severe winds. Wildlife species can be harmed. Collapsed structures can contain combustible building materials, debris, chemicals, machinery, smoke, sewage, or other elements that can damage the environment. Lakeshore beach erosion can occur, along with rip currents in the water, as a result of severe winds. Winds can stir up sediments in waterways that can also disrupt the ecosystem.

Recent Significant Severe Wind Events in Michigan

Various Dates – Lake Michigan (Oceana and Mason Counties)

The twenty-mile span of Lake Michigan between Little Point Sable, at Silver Lake, and Big Point Sable, north of Ludington, has earned a reputation as the "Graveyard of Ships." Beginning with the loss of the Neptune in 1848, through the Armistice (now Veterans') Day Storm of 1940, nearly seventy vessels have gone down in these treacherous waters. Gales and November snow storms have made navigation of this part of the lake a sailor's nightmare. Significant among the losses near Pentwater Harbor were the schooner Wright in 1854, the Minnie Corlett and the Souvenior in 1875, the Lamont in 1879 and the tug Two Brothers in 1912. The freighters William B. Davock, Anna C. Minch and Novadoc were all lost on November 11, 1940.

November 18, 1958 – Lake Michigan

The November 18, 1958 sinking of the 615-foot Carl D. Bradley limestone carrier in Lake Michigan, 60 miles west of the Mackinac Bridge, was due to excessive waves caused by winds up to 100 miles per hour. Mariners theorized that the “working” of the steel hull by 20-foot waves popped the rivets that held the ship’s plates together, causing the large vessel to split in two and sink. Thirty-three of the 35 crewmen onboard died in the accident.

November 10, 1975 – Lake Superior

The November 10**,** 1975 sinking of the freighter Edmund Fitzgerald in Lake Superior was due to excessive waves caused by severe winds exceeding 60 miles per hour. A total of 29 crewmen died in the accident.

July 15-20, 1980 – Southern Lower Michigan

Wind-related damages were so severe in the southern Lower Peninsula from July 15-20, 1980 that a Presidential Major Disaster Declaration was granted for 10 counties. Over 300,000 electrical customers were left without power, some for several days. During the recovery process, almost $6.8 million in public and private assistance was made available to affected local jurisdictions and to residents in the affected areas. Four million dollars in low-interest disaster loans were made available through the Small Business Administration.

April 30, 1984 – Lower Michigan

On April 30, 1984 a windstorm struck the entire Lower Peninsula, resulting in widely scattered damage, 1 death, and several injuries. Wind gusts measured up to 91 miles per hour in some areas. Damage was widely scattered, but extensive, with 6,500 buildings, 300 mobile homes, and 5,000 vehicles being damaged. Over 500,000 electrical customers lost power. In addition, 10-16 foot waves on Lake Michigan caused severe shore erosion, collapsing some cottages and driving many boats aground.

March 27, 1991 – Central and Southern Lower Michigan

On March 27, 1991 severe thunderstorms and accompanying high winds caused considerable damage across a large portion of central and southern Lower Michigan, damaging homes, businesses, farms, and some public facilities. A total of three deaths and 27 injuries were attributed to the storms, and power was lost to 450,000 electrical customers (many for up to one week). The storms also spawned tornadoes and hail in some areas. Damage to homes and businesses was estimated at over $30 million, with almost all of those losses covered by private insurance.

July 7, 1991 – Southern Lower Michigan

On July 7, 1991 a line of severe thunderstorms with very high winds crossed the southern Lower Peninsula. The National Weather Service recorded wind speeds of 60-70 miles per hour, with gusts in several locations exceeding 80 miles per hour. Several million dollars in damage occurred, and over one million electrical customers (more than 10% of the State's population) were left without power, some for several days. In addition, thousands of downed power lines caused significant public safety concerns and burdened an already difficult restoration process.

July 13-15, 1995 – Statewide

From July 13-15, 1995 severe thunderstorms damaged numerous areas of Michigan. These storms, which produced winds up to 100 miles per hour with damaging golf ball-sized hail and severe lightning, damaged hundreds of structures and downed thousands of trees and power lines statewide. Damage was widespread, but the impacts were not severe or extensive enough in any one location to require supplemental disaster assistance. The strong winds produced widespread power outages. More than 400,000 electrical customers in southeast Michigan lost power due to the storms. In Roscommon County, over 100,000 trees were toppled by the winds. Wind gusts in that area were estimated in the 85-100 miles per hour range. One person was killed when her pontoon boat flipped over while attempting to return to its dock. One person was killed in Huron County when a barn collapsed between Bad Axe and Harbor Beach.

April 6-7, 1997 – West Michigan

On April 6-7, 1997, an intense early spring low pressure system moving across the Great Lakes brought gale force winds to much of Lower Michigan. Wind gusts of 50-70 miles per hour created 10-15 foot waves on the Lake Michigan shoreline, causing widespread wind damage and lakeshore beach erosion. Private damage was estimated at $5 million, most of that occurring in a handful of West Michigan counties. The winds downed numerous trees and power lines across the region, causing roof damage to many structures and power outages for nearly 200,000 Consumers Energy electrical customers. The U.S. Army Corps of Engineers estimated that the severe beach erosion resulted in as much as 20 feet of beach loss in some areas. The beach erosion was due in part to the unusually high Great Lakes water levels, nearly 38 inches above average. One injury was later reported in this severe wind event.

July 2, 1997 – South-Central and Southeast Michigan

On July 2, 1997 a series of intense thunderstorms went through south-central and southeast Michigan, spawning severe straight-line winds, several tornadoes, and heavy rainfall. In some areas, the straight-line winds reached speeds of 70-100 miles per hour, causing significant structural damage and massive amounts of debris. The severe storms and the associated impacts caused a total of 16 deaths and 120 injuries. The tornadoes and straight-line winds downed thousands of trees and power lines, which knocked out power to 350,000 electrical customers. A Presidential Major Disaster Declaration was granted for the five county area most severely impacted by the storm event. (See the Tornadoes section for additional details on the tornadoes associated with these severe thunderstorms.)

October 5, 1997 – Delta and Schoolcraft Counties

Severe thunderstorms out of Canada pushed their way through the Upper Peninsula on October 5, 1997, creating numerous microbursts (small, powerful downdrafts) that caused significant damage in Delta and Schoolcraft counties. Winds estimated in excess of 100 miles per hour cut a 12-mile wide swath of destruction in the two counties, downing thousands of trees and damaging 600 buildings and numerous vehicles. Total property, tree and agricultural losses were estimated at $3 million. The U.S. Forest Service reported damage to 9,000 acres of forest. The Michigan Department of Natural Resources suffered 500 acres of tree loss, and 200 acres of corporate forest were also heavily damaged. Fortunately, these microbursts occurred in lightly populated areas, or the threat to life and property might have been much greater.

May 31, 1998 – Southern Lower Peninsula

On May 31, 1998 a derecho raced across the Lower Peninsula around 4:30am, producing widespread 60 to 90 mph wind gusts that caused extensive tree and structural damage and left over 861,000 homes and businesses without electricity. Consumers Energy reported the derecho as the most destructive weather event in its history, leaving over 600,000 of its customers without power. There were four storm-related fatalities and 146 injuries (mostly minor) reported in the state. Statewide, approximately 250 homes and 34 businesses were destroyed and 12,250 homes and 829 businesses were damaged. Damage estimates totaled over $166 million. The highest wind gusts reached 120 to 130 mph in Spring Lake (Ottawa County) and Walker (Kent County), 100 mph in portions of Montcalm County (including Cody Lake and Stanton), and 90 mph in Rockford (Kent County) and Zeeland (Ottawa County). It took up to 10 days to fully restore power to certain areas, including the City of Walker and portions of Montcalm and Gratiot Counties. A Presidential Disaster Declaration was declared for 13 counties.

September 26-27, 1998 – Northern Lower Michigan

During the weekend of September 26-27, 1998, severe thunderstorms ravaged northern Lower Michigan, producing strong winds that damaged or destroyed homes, businesses and public facilities, and downed trees and power lines. Otsego County, specifically the city of Gaylord, was hardest hit, although damage was also reported in Crawford and Charlevoix counties as well. The storm front, which ran along and north of the M-32 corridor from East Jordan to Alpena, was approximately 12 miles wide and 15 miles long. When the front slammed into Gaylord, wind speeds had reached hurricane force of 80-100 miles per hour. The wind was accompanied by brief heavy rainfall and golf ball sized hail. The storm lasted only a few minutes in Gaylord, but the damage was tremendous. Thousands of trees were snapped off at waist level, homes and businesses were torn apart, power lines were downed, and several public facilities were substantially damaged – including the Otsego County Courthouse, which lost half of its roof. Approximately 818 homes were damaged throughout Otsego County, including 47 that were destroyed and 92 that incurred major damage. In addition, the storm injured 11 persons – none seriously. Region-wide, about 12,000 electrical customers lost power. A Governor's Disaster Declaration was granted to the county, to provide state assistance in the debris cleanup effort.

November 10-11, 1998 – Statewide

One of the strongest storms ever recorded in the Great Lakes moved across Michigan on the 10th and 11th of November, 1998, producing strong, persistent winds that damaged buildings, downed trees and power lines, killed one person, and left over 500,000 electrical customers in the Lower Peninsula without power. Wind gusts of 50-80 miles per hour were common, and a peak gust of 95 miles per hour was reported on Mackinac Island. Damage was widespread but relatively minor for a storm of that intensity. However, there were several pockets of significant damage across the state. In Troy, the walls of a church under construction were destroyed. In Flint, a warehouse lost its roof to the wind, and another had its roof damaged. In Mt. Clemens, a boat storage rack collapsed, causing about $500,000 in damage to 20 boats. In Frankfort, on the Lake Michigan shoreline, 80-90 mile per hour wind gusts destroyed a hangar at the City-County Airport ($500,000 in damage) and damaged six private planes. In Lake City, the roof was blown off a hardware store. The U.S. Forest Service reported that at least $10 million worth of timber was lost in the Ottawa and Hiawatha National Forests. The strong winds generated 15-20 foot waves on Lake Michigan, while 8-15 foot waves were reported along the western Lake Superior shoreline. The waves caused considerable beach erosion in both locations.

The extended period of strong winds even affected the water level in Saginaw Bay. By the morning of November 11, the winds had pushed so much water out into Lake Huron that the water level on Saginaw Bay bottomed out 50" below chart datum – over 5 feet below the recent average. The temporary loss of over 5 feet of water in the shallow bay exposed up to one-half of the bay bed, which briefly became dry land during the storm. As the wind died down later in the day, the water level rose again to its more normal level. Coincidentally, this storm system occurred on the anniversary of the storm system that had sunk the freighter Edmund Fitzgerald in Lake Superior in 1975.

May 17, 1999 – Central and Southern Lower Michigan

On May 17, 1999 a strong storm system raced through central and southern Lower Michigan, bringing with it severe winds, heavy rain, and large hail. Wind gusts of 60-70 miles per hour downed numerous trees and power lines, leaving 150,000 homes and businesses without power. Peak wind gusts of 115 miles per hour were recorded near Wyoming, Lansing, and Battle Creek. A wind gust caused a home under construction to collapse in Wyoming, killing one person and injuring another. In Lansing, utility poles along I-496, built to withstand 100 mile per hour winds, were snapped off like twigs, closing parts of the freeway for 26 hours and causing rush hour traffic tie-ups. Response and recovery costs for Lansing city agencies (including the municipal power company) were pegged at $1.5 million.

July 4-5, 1999 – Several Northern States

The Boundary Waters-Canadian Derecho, also commonly called the Boundary Waters Blowdown, was an international Derecho that occurred during the afternoon and evening hours of July 4 and the early morning hours of July 5, 1999. It was classified as a progressive Derecho and it traveled over 1300 miles in 22 hours through Minnesota, Wisconsin, Michigan, Ontario, Quebec and Maine. There was also a tremendous amount of lightning associated with this Derecho, around 6,000 lightning strikes per hour. This event was one of the northernmost progressive Derechos to have ever been recorded. It caused $100 million in damage, killed 2 people and injured 70. Over 700,000 homes and businesses lost power from the event.

July 24-25 and 31, 1999 – Southern Lower Michigan

During the last two weekends of July 1999, a series of severe thunderstorms, fueled by high temperatures and extreme humidity, moved across southern Lower Michigan. The storms produced strong wind gusts (estimated at 60-70 miles per hour), heavy rainfall, and hail in some areas. Most of the damage caused by the wind involved downed trees and power lines. A total of 430,000 electrical customers were left without power after the two weekend storms, many for more than 24 hours. Unfortunately, the outages occurred at a time when temperatures were soaring past 90 degrees and humidity was unbearably high. Many electrical customers lost large amounts of perishable food to spoilage. Restoration efforts after the July 24 storms were further complicated when another series of storms struck on the 25th, forcing utility crews to temporarily halt their restoration efforts. Damage to homes, businesses, vehicles, and boats was reported in southeast Michigan and the Saginaw Bay area. In Detroit, heavy rainfall flooded freeway underpasses with up to two feet of water, while golf ball sized hail was reported in Kawkawlin, Bay City, Zilwaukee, Goodrich, and Southfield.

May 9, 2000 – Southeast Michigan

During the afternoon and evening hours of May 9, 2000, an outbreak of severe thunderstorms (with winds gusting to 70 miles per hour) struck southeast Michigan, causing considerable damage across the region. The storm front produced a combination of straight-line winds and some reported tornadoes, accompanied by large, damaging hail in many locations. In Lenawee County, strong winds destroyed several barns, flipped over a mobile home and recreational vehicle, caused numerous trees to fall on homes, destroyed grain bins, and destroyed one airport hangar and damaged two others. In Monroe County, dozens of trees were downed and a railroad depot was destroyed. In Washtenaw County, hundreds of trees were downed and a church and a grocery store were damaged. In Wayne County, a hangar at Detroit Metropolitan Airport collapsed, damaging the plane inside. Numerous other localities within Wayne County suffered damage to homes and businesses. All totaled, the storms left more than 200,000 electrical customers without power, injured at least six persons, and caused several million dollars in property damage.

October 24, 2001 – Southern Lower Michigan

On October 24, 2001, much of Michigan began experiencing severe weather as the result of a strong cold front colliding with warm, moist air. The result was widespread strong winds (in excess of 50 miles per hour) and severe weather throughout the state, but particularly so in southern Lower Michigan where severe thunderstorm warnings were issued for 13 counties, and tornado warnings were issued for seven counties. Although numerous funnel clouds were sighted across the region, only two actually touched down – one affecting Livingston and Oakland Counties along a 15-mile path, and the other affecting Saginaw County. The vast majority of the damage produced by this storm system was from straight-line winds, the strongest of which were reported in Lansing and estimated at 120 miles per hour.

Region-wide, the storms killed two persons and injured at least 20 others, caused extensive flooding of roads and streets, downed thousands of trees and power lines (leaving 195,000 electrical customers without power), closed schools and businesses, and damaged hundreds of cars, homes and businesses, and public buildings. The areas most heavily impacted by this storm system included the counties of Berrien, Cass, and Kalamazoo, and the cities of Lansing and East Lansing. A Governor's Disaster Declaration was issued for Kalamazoo County to provide supplemental state assistance for debris removal and cleanup.

July 31-August 2, 2002 – Central Michigan and Upper Peninsula

During the last day in July, severe weather hit central Michigan and the Upper Peninsula. The National Weather Service issued tornado warnings for seven counties in central Michigan. Funnel clouds were reported along a 120-mile stretch extending from Howard City to Onaway. Golf ball-size hail fell in Escanaba and thunderstorms soaked Houghton with 1.25" of rain in a two-hour period. About 14,000 Upper Peninsula Power Company customers lost electricity for several days due to 70 mile per hour winds that toppled trees and power lines in the western Upper Peninsula. Some Houghton customers were blacked out when high winds tore the metal roof off a Frito-Lay warehouse and it sliced through nearby power lines. From Tuesday night through midday Thursday, the National Weather Service issued 44 severe weather warnings for various parts of the Upper Peninsula.

May 11, 2003 – Southeast Michigan

A strong cold front moved through the Great Lakes region during the morning of the May 11, 2003. Wind gusts of 55 to 60 mph were estimated across much of Wayne and Washtenaw counties. The rest of Southeastern Michigan generally had estimated wind gusts of 45 to 50 mph. The winds caused several trees to blow down across the area and several thousand homes and businesses across the area to lose power. The strong winds were also blamed for a hydrochloric acid leak from a plant in Ypsilanti. Investigators concluded that the high winds ripped a chunk of the plant's roof loose, smashing it into a distribution pipe, which caused roughly 100 gallons of acid to leak out.

July 4-6, 2003 – Southern Lower Michigan

A line of thunderstorms that developed over Wisconsin made its way across Lake Michigan over the Independence Day weekend, bringing wind gusts of more than 60 miles per hour, knocking down trees and leaving more than 200,000 customers without electricity. Power went out during one of the warmest weeks of the summer, causing many citizens to lose large amounts of perishable foods. In Brighton Township, residents of a subdivision were without running water for several days because they relied on electricity to operate wells. A small stretch of beaches in southwest Michigan turned deadly over the weekend, as 10 swimmers drowned from the storm-powered undercurrents. On July 4, more swimmers drowned in one day than drown all summer, on average, in southwest Michigan. Nine fatal car accidents also occurred over the holiday weekend due to the severe weather.

August 1, 2003 – Southern Lower Michigan

Severe thunderstorms and winds up to 77 miles per hour swept through southern Lower Michigan on August 1, 2003, killing two persons. One man was killed while he was walking when high winds snapped off a tree limb, hitting him on the head. A woman was pronounced dead at a local hospital after being struck by lightning. A young boy survived a lightning strike the same day. The high winds caused about 127,000 electrical customers to lose power - most of whom had it restored within a couple of days.

November 11, 2003 – Southeast Lower Michigan

Wind gusts up to 74 miles per hour knocked down trees and power lines, causing a loss of power for more than 370,000 electrical customers in southeast Michigan. The harsh weather conditions forced many school districts to cancel classes. A live power line fell across eastbound Interstate 94 near Monroe, forcing the closure

of the highway and causing a major traffic jam near Detroit Metropolitan Airport. Detroit's Department of Public Works received 73 telephone calls reporting trees down and other damage.

November 6, 2005 – Southeast Michigan

On November 6, 2005 a deep and rapidly intensifying storm system moved through Southeast Lower Michigan during the morning. High winds along the associated cold front knocked down trees, leading to approximately 200,000 power outages. Winds were sustained out of the southwest at 30 to 40 mph, with gusts as high as 60 mph from mid to late morning. Street signs were toppled, traffic lights were sent spinning, and power lines were split. Many streets and roads had to be temporarily closed until trees blocking the way could be cleared. Property damage was estimated at $4.2 million.

May 15, 2007 – Southern Lower Michigan

Severe thunderstorm winds affected many counties and measured as high as 83 knots (at the Three Rivers Airport in St. Joseph County). Significant damages were caused at locations as diverse as Centreville, Schoolcraft, North Aurelius, and Howell. One mile north of Essexville (Bay County), a power plant's coal stacker was reported as having been destroyed when it was toppled over by strong winds, with damages estimated at $1.5 million.

June 6, 2008 – Southern Lower Michigan

Numerous thunderstorms produced damaging winds of up to 65 knots. The strongest winds were reported at Howell and Saginaw. The greatest damages occurred in the Saginaw area, where 12,000 residents lost electricity. Two miles north of Carrollton, dozens of trees were blown down, some knocking down power lines, some falling onto houses, some blocking roads, and one falling onto a car and injuring its two occupants. An entire roof was blown off a commercial building near the intersection of Stevens and Hamilton.

June 8, 2008 – Southern Lower Michigan

A derecho swept across many counties in the southern Lower Peninsula, involving winds as high as 74 knots (at Marine City). There were also tornadoes associated with this system. Along with an estimated $100 million in total damages, several casualties were caused by the storm systems, and more than 10,000 persons were without power for a week or more. This was the worst such wind event of the decade. Thousands of trees were lost, and great property damage was caused as they toppled onto houses and cars. One mile west of Spring Lake, a car was struck by a tree while it was being driven, killing the driver and injuring the passenger. A pedestrian was also killed by a falling tree, a mile southeast of Harrisburg. Numerous power lines were down, and boats were overturned in the water.

August 9, 2009 – Ottawa and Kent Counties

On August 9, 2009 severe thunderstorms developed across Ottawa and Kent Counties, resulting in hundreds of trees being blown down and numerous utility poles and wires taken down by 60 to 80 mph winds. Fruitport took the brunt of the storm, with wind gusts of 70 to 80 mph lasting for about 10 minutes. Numerous homes were heavily damaged by falling trees. Significant damage to apple orchards occurred west of Sparta. The storm complex also produced an EF-0 tornado path 35 miles long, and up to 9 miles wide.

July 18, 2010 – Kent County

On July 18, 2010 a NWS storm survey team concluded that a series of wet micro bursts across southwestern Kent County had produced wind gusts ranging from 60 up to 80 mph, brought down several trees and power lines in the Wyoming and Cutlerville areas, and flipped over and destroyed 8 wood and metal sheds at a store near Cutlerville. A tornado damaged a home and broke or uprooted several trees just northeast of Wayland. A roof was lifted off of a garage in Wyoming, a shed was destroyed, and some structural damage occurred to one home, due to wind gusts estimated to be as much as 80 mph.

May 29, 2011 – Mid-Michigan (Calhoun, Kalamazoo, Eaton, and Ingham Counties)

Severe thunderstorms resulted in straight-line winds of up to 85 to 100 mph, causing extensive damage across multiple counties. A state of emergency was declared for Calhoun County due to widespread wind damage. Nearly 40,000 people across Calhoun County had lost power due to wind and lightning damage. While no lives were lost, over 600 properties were damaged and 76 homes and 4 businesses in the Battle Creek area were destroyed. The total damage estimates were over $29M, approximately $25M of which was in Calhoun County.

July 11, 2011 – Western Michigan (Kent, Ottawa, and Kalamazoo Counties)

Two separate bow echoes moved across the western Lower Peninsula on July 11, producing numerous reports of wind damage. The first bow echo moved onshore north of Muskegon shortly after daybreak. The second, more destructive bow echo raced east from northern Illinois across far southern Lake Michigan and southern lower Michigan, resulting in numerous reports of downed trees and power lines. One person lost his life in Cutlerville when a tree fell in the garage he was in. Wind gusts up to 80mph were reported and the storm resulted in approximately $8M damage—mostly in Kent County ($5M) but also in Ottawa ($2M) and Kalamazoo County ($1M).

January 19th, 2013 – Southeast Michigan

An intense Arctic Front swept through southeast Michigan around Midnight of January 19th, with westerly winds gusting as high as 60 mph across much of the area during the early morning hours of January 20th. Trees and power lines were downed across individual counties, leading to power outages in excess of 120,000 DTE customers during the peak of the winds. The storm resulted in more than $7.5M damage across 7 counties, including $2M in Wayne County, $1.5M each in Oakland and Macomb Counties, and $1M each in Tuscola, Huron, Genesee, and St. Clair.

Programs and Initiatives

Note: Many of the programs and initiatives designed to mitigate, prepare for, respond to, and recover from tornado effects have the dual purpose of also protecting against severe straight-line winds. As a result, there is some overlap in the narrative programs and initiatives descriptions for each respective hazard. This redundancy allows each hazard section to stand alone, eliminating the need to refer to other hazard sections for basic information.

<u>National Weather Service Doppler Radar</u>

The National Weather Service (NWS) has completed a major modernization program designed to improve the quality and reliability of weather forecasting. The keystone of this improvement is Doppler Weather Surveillance Radar, which can more easily detect severe weather events that threaten life and property – including severe winds. Most important, the lead time and specificity of warnings for severe weather have improved significantly.

Doppler technology calculates both the speed and the direction of motion of severe storms. By providing data on the wind patterns within developing storms, the new system allows forecasters to better identify the conditions leading to severe weather such as tornadoes and severe straight-line winds. This allows early detection of the precursors to severe storms, as well as information on the direction and speed of storms once they form.

National Weather Service Watches/Warnings

The National Weather Service issues severe thunderstorm watches for areas where the meteorological conditions are conducive to the development of severe thunderstorms. People in the watch area are instructed to stay tuned to National Oceanic and Atmospheric Administration (NOAA) weather radio and local radio or television stations for weather updates, and watch for developing storms. Once radar or a trained Skywarn spotter detects the existence of a severe thunderstorm, the National Weather Service will issue a severe thunderstorm warning. The warning will identify where the storm is located, the direction in which it is moving, and the time frame during which the storm is expected to be in the area. Persons in the warning area are instructed to seek shelter immediately.

The State and local government agencies are warned via the Law Enforcement Information Network (LEIN), NOAA weather radio, and the Emergency Managers Weather Information Network (EMWIN). Public warning is provided through the Emergency Alert System (EAS). The National Weather Service stations in Michigan transmit information directly to radio and television stations, which in turn pass the warning on to the public. The National Weather Service also provides detailed warning information on the Internet at www.weather.gov, where an interactive map can be used.

Public Warning Systems

Numerous communities in Michigan have outdoor warning siren systems in place to warn the public about impending tornadoes and other hazards. Most of these systems were originally purchased to warn residents of a nuclear attack, but that purpose was expanded to include severe weather hazards as well. These systems can be very effective at saving lives in densely populated areas where the siren warning tone is most audible. In more sparsely populated areas where warning sirens are not as effective, communities are turning to NOAA weather alert warning systems to supplement or supplant outdoor warning siren systems. Unfortunately, a large number of communities across the state do not have adequate public warning systems in place to warn their residents of severe weather or other hazards. Federal funding specifically allocated to assist communities in the purchase of public warning systems has effectively disappeared, leaving many communities unable to purchase adequate systems to warn their residents of impending danger.

Attempting to fill some of that funding void, the State of Michigan has used federal Hazard Mitigation Grant Program (HMGP) funds to assist local communities in purchasing public warning systems. To date, HMGP funds have been used to purchase and install more than 80 outdoor warning sirens, over 1,000 NOAA weather alert monitors for schools, hospitals and places of public assembly, four NOAA weather radio transmitters, and several other early warning systems. Communities that received funding for these projects were encouraged to implement a warning education program to ensure that residents know what to do once they receive warning of an impending hazardous event. Because HMGP funds must be used to fund a wide variety of mitigation projects, the amount of funds available to fund warning systems is limited to a small percentage of the overall available grant funds allocated to the state. The HMGP funds are provided on a 75% federal, 25% local cost share. A Presidential major disaster declaration is required to activate the HMGP funding. As a result, the funding stream may not always be available in the future. In addition, state mitigation priorities may change over time, putting public warning systems at a lower priority than other mitigation projects. However, the HMGP does provide at least one possible avenue for assisting communities in enhancing their local public warning capability.

Severe Weather Awareness Week

Each spring, the Emergency Management and Homeland Security Division, Department of State Police, in conjunction with the Michigan Committee for Severe Weather Awareness, sponsors Severe Weather Awareness Week. This annual public information and education campaign focuses on severe weather events such as tornadoes, thunderstorms, lightning, hail, flooding and high winds. Informational materials on severe winds and other weather hazards are disseminated to schools, hospitals, nursing homes, other interested community groups and facilities, and the general public.

Manufactured Home Anchoring

Manufactured homes are vulnerable to wind damage if they are not properly anchored down. As a result, a major national effort has been initiated to encourage the structural anchoring or “tie down” of manufactured homes. The Michigan Manufactured Housing Commission Administrative Rules (R 125.1602, Subsection 5) require new manufactured home installations in floodplains to be structurally anchored to a foundation. Through this requirement,

the possibility of damage from wind is minimized. Unfortunately, structures outside designated floodplains do not have to comply with the anchoring provision, although many owners choose to comply voluntarily. It should also be noted that local communities have the option of adopting an ordinance that requires anchoring of manufactured home installations located outside a designated floodplain. State anchoring system standards are outlined in Administrative Rules R 125.1605 through R 125.1608.

Electrical Infrastructure Reliability

One of the major problems associated with severe winds is the loss of electric power. As mentioned previously, Michigan has had numerous widespread and severe electrical power outages caused by severe winds, and several of those outages have resulted in upwards of 500,000 electrical customers (more than 5% of the State's population) being without power for several hours to several days at a time. Wind-related damage to electric power facilities and systems is a concern that is being actively addressed by utility companies across the state. Detroit Edison, Consumers Energy and other major electric utility companies have active, ongoing programs to improve system reliability and protect facilities from damage by severe winds and other hazards. Typically, these programs focus on trimming trees to prevent the encroachment of overhead lines, strengthening vulnerable system components, protecting equipment from lightning strikes, and placing new distribution lines underground. The Michigan Public Service Commission (MPSC) monitors power system reliability to help minimize the scope and duration of power outages.

Structural Bracing and Wind Engineering

One of the best ways to protect buildings from severe wind damage is to install structural bracing and metal connectors (commonly called hurricane clips) at critical connecting points in the frame of the structure. Typically, this involves adding extra gable end bracing at each end of the structure, anchoring the roof rafters to the walls with metal connector straps, and properly anchoring the walls and sill plate to the foundation. This extra bracing helps ensure that the roof stays on the structure, and the structure stays anchored on its foundation. Experience in high wind events has shown that once the roof begins to peel away from the walls, or the building begins to move off its foundation due to extreme lateral wind forces, major structural damage occurs. If the damage continues unabated, the building can end up being a total loss.

Urban Forestry and Tree Maintenance Programs

Urban forestry programs can be very effective in minimizing storm damage caused by falling trees or tree branches. In almost every severe wind event, falling trees and branches cause power outages and clog public roadways with debris. However, a properly designed, managed and implemented urban forestry program can help keep tree-related damage and impact to a minimum. To be most effective, an urban forestry program should address tree maintenance in a comprehensive manner, from proper tree selection, to proper placement, to proper tree trimming and long-term care.

Every power company in Michigan has a tree trimming program, and numerous local communities have some type of tree maintenance program. The electrical utility tree trimming programs are aimed at preventing encroachment of trees and tree limbs within power line rights-of-way. Typically, professional tree management companies and utility work crews perform the trimming operations. At the local government level, only a handful of Michigan communities have actual urban forestry departments or agencies. Rather, crews from the public works agency or county road commission perform the bulk of the tree trimming work.

When proper pruning methods are employed, and when the work is done on a regular basis with the aim of reducing potential storm-related damage, these programs can be quite effective. Often, however, tree trimming work is deferred when budgets get tight or other work is deemed a higher priority. When that occurs, the problem usually manifests itself in greater storm-related tree debris management problems down the line.

Hazard Mitigation Alternatives for Severe Winds

- Increased coverage and use of NOAA Weather Radio.
- Public early warning systems and networks.
- Tree trimming and maintenance to prevent limb breakage and safeguard nearby utility lines. (Ideal: Establishment of a community forestry program with a main goal of creating and maintaining a disaster-resistant landscape in public rights-of-way.)
- Buried/protected power and utility lines. (NOTE: Where appropriate. Burial may cause additional problems and costs in case of breakage, due to the increased difficulty in locating and repairing the problem.)

- Using appropriate wind engineering measures and construction techniques (e.g. structural bracing, straps and clips, anchor bolts, laminated or impact-resistant glass, reinforced entry and garage doors, window shutters, waterproof adhesive sealing strips, and interlocking roof shingles) to strengthen public and private structures against severe wind damage.
- Proper anchoring of manufactured homes and exterior structures such as carports and porches.
- Construction of concrete safe rooms in homes and shelter areas in mobile home parks, fairgrounds, shopping malls, or other vulnerable public areas.

Tie-in with Local Hazard Mitigation Planning

Because many means of implementing mitigation actions occur through local activities, this updated MHMP places additional emphasis on the coordination of State-level planning and initiatives with those taking place at the local level. This takes two forms:

1. The provision of guidance, encouragement, and incentives to local governments by the State, to promote local plan development, and
2. The consideration of information contained in local hazard mitigation plans when developing State plans and mitigation priorities.

Regarding the first type of State-local planning coordination, MSP guidance has included the "Local Hazard Mitigation Planning Workbook" (EMD-PUB 207), which is currently being updated for release by 2015. For the second type of State-local planning coordination, a section later in this plan summarizes hazard priority information as it has been reported in local hazard mitigation plans. Here, it will merely be noted that severe winds were identified as one of the most significant hazards in local hazard mitigation plans for the following counties: Alger, Allegan, Antrim, Arenac, Benzie, Berrien, Branch, Calhoun, Cass, Charlevoix, Clare, Crawford, Delta, Dickinson, Eaton, Emmet, Genesee, Grand Traverse, Gratiot, Huron, Ingham, Isabella, Kalkaska, Kent, Keweenaw, Lake, Lapeer, Leelanau, Lenawee, Livingston, Mackinac, Macomb, Mason, Midland, Missaukee, Monroe, Muskegon, Newaygo, Oakland, Oceana, Ogemaw, Oscoda, Ottawa, Presque Isle, Roscommon, Saginaw, Shiawassee, Tuscola, Van Buren, Washtenaw, Wayne, Wexford (52 counties).

Tornadoes

An intense rotating column of wind that extends from the base of a severe thunderstorm to the ground.

Hazard Description

Tornadoes are rapidly rotating columns of air that form most often in some severe thunderstorms during Michigan's warm months. Tornadoes are high-profile hazards that can cause catastrophic damage to either a limited or an extensive area. A tornado can have winds in excess of 300 miles per hour and can have widths over one mile. The deaths and injuries associated with tornadoes have declined since the 1950s, thanks to advances in severe weather forecasting and technology improvements, but tornadoes can still be deadly killers. Although tornado deaths have decreased, tornado damages have increased in recent years, since a larger part of the country's land area contains developments with each passing year.

There can be wide sections of a community completely destroyed by one or more tornadoes. Neighborhoods can be reduced to piles of splintered trees and homes, and a junkyard of twisted metal objects. A strong tornado can level everything in its path. Communities need to be prepared for the possibility of having many residents without homes, areas with no power or phone lines, a series of burst pipes, and a gigantic amount of wooden and metallic debris to clean up (in patterns that are both scattered and concentrated).

It should be kept in mind that winds are invisible until they pick up a sufficient amount of material that can allows their patterns to be seen, and it is this carried material that provides a tornado with a visible form that is easy to recognize. Funnel clouds can be invisible except for the liquid, dust, and debris that they carry. Therefore, a tornado can be present but not yet discernable to nearby persons. This is one reason why tornado warnings need to be taken seriously. A tornado's initial presence might only be directly observed by its effects upon things at ground level, with the main funnel cloud visibly forming only after enough material has been swept up from the ground. Many persons have placed themselves at risk by not realizing that tornadoes do not always appear in their classic, fully visible form. That classic darkly visible form is merely the one that is most easily discernable in photographs, and is therefore the form that is most widely recognized from such photographs and video. Moreover, tornadoes often reach beyond existing visible funnels (and multiple tornadoes can form simultaneously).

Hazard Analysis

Tornadoes in Michigan are most frequent in the spring and early summer when warm, moist air from the Gulf of Mexico collides with cold air from the polar regions to generate severe thunderstorms. These thunderstorms often produce the violently rotating columns of wind known as funnel clouds. Winds that converge from different directions, heights, or at different speeds are the source of the spinning pattern that gets concentrated as distinct funnels of wind. Michigan lies at the northeastern edge of the nation's primary tornado belt, which extends from Texas and Oklahoma through Missouri, Illinois, Indiana, and Ohio. Most of a tornado's destructive force is exerted by the powerful winds that knock down walls and lift roofs from buildings in the storm's path. The violently rotating winds then carry debris aloft that can be blown through the air as dangerous missiles, which provides the other mechanism by which tornadoes can cause such severe destruction.

A tornado may have winds of over 200 miles per hour, and this is the source of their destructive power. Although a tornado may have an interior air pressure that is 10-20% below that of the surrounding atmosphere, the effect of this difference is insignificant compared with the force directly applied by the winds. (The old belief that opening windows to equalize air pressure was a misguided and harmful one—closer analysis of filmed images and damage patterns has since revealed that it is the force of winds that lift eaves and break down walls which causes some structures to appear to implode or explode under a direct tornado strike.) The typical length of a tornado path is approximately 16 miles, but tracks much longer than that – even up to 200 miles – have been reported. Tornado path widths are generally less than one-quarter mile wide. Typically, tornadoes last only a few minutes on the ground, but those few minutes can result in tremendous damage and devastation. Historically, tornadoes have

resulted in tremendous loss of life, with the mean national annual death toll being 87 persons. Property damage from tornadoes is in the hundreds of millions of dollars every year.

Tornado intensity is measured on the Enhanced Fujita Scale, which examines the damage caused by a tornado on homes, commercial buildings, and other man-made structures. The Enhanced Fujita Scale rates the intensity of a tornado based on damaged caused, not by its size. It is important to remember that the size of a tornado is not necessarily an indication of its intensity. Large tornadoes can be weak, and small tornadoes can be extremely strong, and vice versa. It is very difficult to judge the intensity and power of a tornado while it is occurring. Generally, that can only be done after the tornado has passed, using the Enhanced Fujita Scale as the measuring stick. The Enhanced Fujita Scale is presented in the following table.

Although tornadoes are most commonly reported between 3pm and 9pm, they can occur at any time. Although they generally exist at the trailing edge of a thunderstorm, it is possible for them to be present in other locations and less readily recognized weather patterns.

The Enhanced Fujita Scale of Tornado Intensity

EF-Scale Number	Intensity Descriptor	Wind Speed (mph)	Type/Intensity of Damage
EF0	Gale tornado	65-85	Light damage. Some damage to chimneys; breaks branches off trees; pushes over shallow-rooted trees; damages sign boards.
EF1	Weak tornado	86-110	Moderate damage. The lower limit is the beginning of hurricane wind speed; peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos pushed off the roads; attached garages may be destroyed.
EF2	Strong tornado	111-135	Considerable damage. Roofs torn off frame houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; light object missiles generated.
EF3	Severe tornado	136-165	Severe damage. Roof and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted; heavy cars lifted off ground and thrown.
EF4	Devastating tornado	166-200	Devastating damage. Well-constructed houses leveled; structures with weak foundations blown off some distance; cars thrown and large missiles generated.
EF5	Incredible tornado	Over 200	Incredible damage. Strong frame houses lifted off foundations and carried considerable distances to disintegrate; automobile-sized missiles fly through the air in excess of 100 meters; trees debarked; steel reinforced concrete structures badly damaged; incredible phenomena will occur.

NOTE: When describing tornadoes, meteorologists often classify the storms as follows:
EF0 and EF1 = weak tornado; EF2 and EF3 = strong tornado; EF4 and EF5 = violent tornado

(Source: The Tornado Project; Storm Data, National Climatic Data Center)

According to the National Weather Service (NWS), since 1950 the vast majority of tornadoes that occurred in the United States (approximately 74%) were classified as weak tornadoes (EF0 or EF1 intensity). Approximately 24% were classified as strong tornadoes (EF2 or EF3 intensity), and only 3% were classified as violent tornadoes (EF4 or EF5 intensity). Unfortunately, those violent tornadoes, while few in number, caused about 65% of all tornado-related deaths nationally. Strong tornadoes accounted for another 33% of tornado-related deaths, while weak tornadoes caused only 1% of tornado-related deaths. If the data prior to 1950 is examined, the percentage of deaths attributable to violent tornadoes climbs drastically. That is largely due to the fact that tornado forecasting and awareness programs were not yet established. As a result, it was much more likely for death tolls from a single tornado to reach several hundred.

Maps and tables at the end of this section show the breakdown of tornadoes by county for the period from 1950 to 2009, and also for the more recent period from 1996 to 2013. An examination of the map and tables indicates that tornadoes occur more frequently in the southern-half of the Lower Peninsula than any other area of the state. This

area could be referred to as Michigan's "tornado alley." Most tornadoes in Michigan come from the southwest and travel northeast, with many passing through the most densely populated areas of the state.

Records indicate that tornadoes in Michigan have been more deadly than in many other tornado-prone states. Part of that is influenced by the high death toll associated with the June 8, 1953 and April 11, 1965 tornadoes. However, part is also due to the fact that several tornadoes have hit relatively densely populated areas of Michigan, increasing the fatalities. As for when those deaths occurred, the table below provides a good indicator, based upon about 55 years of events, and reveals that 96% of the state's tornado-related deaths have occurred in the months of April, May and June. June has been Michigan's most deadly tornado month, with 54% of all deaths. If the June 8, 1953 tornado death toll of 115 people is excluded, April becomes the most deadly tornado month with 77 deaths (32% of the total). Note that a tornado can sometimes appear during winter months.

Tornado-Related Deaths in Michigan, by Month: 1950-May 2005

JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	TOTAL
0	**0**	**3**	**77**	**23**	**130**	**3**	**1**	**1**	**0**	**1**	**0**	**239**

Source: National Climatic Data Center

In Michigan, tornadic activity is a real threat; there were 954 tornadoes reported from 1950 to 2005. There have been 239 related deaths, but fewer than 10% of these occurred after 1980, probably due to improved warning systems and public knowledge of the threats. Although there have been fewer deaths and injuries recently, property damages have remained very heavy, though not consistently predictable. As recent tornado events in Joplin, MO (2011) and Norman, OK (2013) showed, it is still possible to have a destructive tornado directly impact urbanized areas, as had occurred in Michigan's worst 1953 event.

The geographic risk for tornadoes in Michigan is far greater in the southern half of the state than in the northern half. All counties south of Kent and Genesee Counties have had at least 14 tornadoes touch down in their boundaries from 1950-2009 (with the exception of St. Joseph County, having only 9 tornadoes). Genesee (41), Lenawee, Kent and Oakland Counties (31 each) have had the highest total of tornadoes in the state. When adjusting for the size of the county, the highest-risk counties on a per-land area basis becomes Genesee (10.5 tornadoes per 10,000 square miles), Monroe (8.4), and Ingham and Berrien (8.0 each). North of Flint and Grand Rapids, only Saginaw County has had a relatively high occurrence of tornadoes, with 21. The extreme northern portion of the Lower Peninsula and the Upper Peninsula overall have a lower risk of tornadoes, with all counties having 11 or fewer tornadoes (although Alpena and Ogemaw had 14) over the 60-year time span. Nevertheless, the tornado impact can be disastrous for any Michigan county. Oscoda County, which has a relatively low frequency of tornadoes, suffered devastating damage from a tornado strike at the town of Comins, in 1999.

Although tornadoes technically cannot be prevented, contained, or completely predicted, their potential impacts on Michigan's citizens and communities can certainly be reduced. In general, improved surveillance and warning systems implemented by the National Weather Service and emergency management agencies, coupled with extensive public education campaigns, have been very effective in keeping the death toll down in recent years. However, this is not to say that a major death toll could not occur again if a strong tornado should strike a highly populated area. History has clearly shown that tornadoes must always be treated with the utmost respect and caution. Other initiatives, such as structural bracing, urban forestry practices, manufactured home anchoring, and strengthening electrical system components, can help to reduce public and private property damage.

Like severe straight-line wind events, tornado disasters require that communities plan and prepare for the mass care of residents left without electrical power and the clearance and disposal of tree and construction debris from roadways. Those are the two primary challenges facing Michigan communities. The planning and preparedness effort should include the identification of necessary mass care facilities and supplies, as well as debris removal equipment and services. In addition, communities should develop debris management procedures (to include the

identification of multiple debris storage, processing and disposal sites) so that the debris stream can be handled in the most expedient, efficient, and environmentally safe manner possible.

National Weather Service data indicates that Michigan has experienced 923 tornadoes and 242 related deaths during the period from 1950 to 2009, an average of 15 tornadoes and 4 tornado-related deaths per year. The greatest number of tornadoes per year during that period occurred in 1974, with 39 tornadoes (8 of which occurred on April 3). The least number occurred in 1959, with only 2 tornadoes. From 1950 to March 2005, Michigan experienced 508 "tornado days" (defined as days in which tornadoes are observed), an average of 9 days per year.

The map and table at the end of this section list the number of tornadoes experienced in each Michigan county for the period 1950-2009. (Note: these totals do not correct for boundary-crossing tornadoes; therefore, a tornado that crosses a county boundary will be "double counted" in the totals for each county.)

All counties south of Kent and Genesee Counties have had at least 14 tornadoes touch down in their boundaries from 1950-2009 (with the exception of St. Joseph County, having only 9 tornadoes). Genesee (41), Lenawee, Kent and Oakland Counties (31 each) have had the highest total of tornadoes in the state. When adjusting for the size of the county, the highest-risk counties on a per-land area basis become Genesee (10.5 tornadoes per 10,000 square miles), Monroe (8.4), and Ingham and Berrien (8.0 each). North of Flint and Grand Rapids, only Saginaw County has had a relatively high occurrence of tornadoes, with 21. The extreme northern portion of the Lower Peninsula and the Upper Peninsula overall have a lower risk of tornadoes, with almost all counties having 11 or fewer tornadoes (although Alpena and Ogemaw had 14) over the 60-year time span. Nevertheless, the tornado impact can be disastrous for any Michigan county.

In terms of intensity, Michigan's tornado experience since 1950 has essentially mirrored the national experience. Approximately 67% of all Michigan tornadoes have been weak tornadoes (EF0 or EF1 intensity), while 29% have been strong tornadoes (EF2 or EF3 intensity) and 4% have been classified as violent tornadoes (EF4 or EF5 intensity). However, those few violent tornadoes have been responsible for 88% of Michigan's tornado-related deaths. Strong tornadoes (EF2 or EF3 intensity) have accounted for approximately 11% of the deaths, while weak tornadoes (EF0 or EF1 intensity) have caused only 1% of all tornado-related deaths. Those patterns are fairly consistent with the national averages, although Michigan has had more strong and violent tornadoes (approximately 33% in Michigan vs. 27% nationally), and its death toll from violent tornadoes is slightly higher than the national average (67% in Michigan vs. 65% nationally). Michigan's higher than average death toll from violent tornadoes is largely due to the tragic storm events that occurred in Flint in 1953 and across southern Michigan in 1965 (see the Significant Tornadoes section for more details). Unfortunately, Michigan's tornado experience to date has been more deadly than in many other tornado-prone states across the country. Michigan's tornado events have earned it a top ten ranking in three national tornado statistical categories: (1) single killer tornadoes, (2) deaths per 10,000 square miles, and (3) killer tornadoes as a percent of all tornadoes.

Killer Tornadoes: Selected Top Ten Lists

Rank	Single Killer Tornadoes (Date, State, # Deaths, F-Scale)	Tornado Deaths Per 10,000 Sq. Miles	Killer Tornadoes as % of all Tornadoes
1	March 18, 1925, MO-IL-IN, 695 deaths, F5	Massachusetts	Tennessee
2	May 7, 1840, LA-MS, 317 deaths, F?	Mississippi	Kentucky
3	May 27, 1896, MO-IL, 255 deaths, F4	Indiana	Arkansas
4	April 5, 1936, MS, 216 deaths, F5	Alabama	Ohio
5	April 6, 1936, GA, 203 deaths, F4	Ohio	Alabama
6	April 9, 1947, TX-OK-KS, 181 deaths, F5	**Michigan**	Mississippi
7	May 22, 2011, MO, 158 deaths, F5	Arkansas	North Carolina
8	April 24, 1908, LA-MS, 143 deaths, F4	Illinois	**Michigan**
9	June 12, 1899, WI, 117 deaths, F5	Oklahoma	New York
10	**June 8, 1953, MI, 116 deaths, F5**	Kentucky	Massachusetts

Source: NOAA http://www.spc.noaa.gov/faq/tornado/killers.html ; The Tornado Project / National Weather Service

Michigan's tornado death toll is significantly influenced by two disasters: one in Flint on June 8, 1953 that caused 115 deaths and $19 million in damage, and a series of tornadoes in southern Michigan on April 11, 1965 (Palm Sunday) that caused 53 deaths and $51 million in damage. (See the tables below and on the following pages for more information on these and other significant tornadoes in Michigan.) Fortunately, the trend over time has generally been toward a lesser number of tornado deaths. During the 1950s, 153 deaths occurred, when the total number of tornadoes recorded was 109. In the 1960s, the number of deaths dropped to 66 although the number of tornadoes went up a bit, to 123. In the 1970s, despite a whopping 251 tornadoes, only 8 deaths resulted, and the trend has stayed quite low ever since. The 1980s saw 10 tornado deaths and 212 tornado events, but the 1990s saw only 2 deaths among 173 events. During the 2000s, a total of 3 deaths occurred, and the total number of events numbered 160.

A list of tornadoes, by county, for the years 1950 to 1995, can be found here: http://www.tornadoproject.com/alltorns/mitorn.htm, while a list of tornado events from 1996 to present can be obtained from this online database (the source of a table at the end of this section): https://www.ncdc.noaa.gov/stormevents/

Since 1996, Michigan has averaged about 16 tornadoes per year. An average of about 4 tornado deaths and 60 injuries takes place each year, in Michigan (when using historical data back to 1950). Annual property damage averages more than $19 million per year, based upon events from 1996-2013. (NOTE: As with other weather events, these figures are conservative, actual totals are likely to be higher.) Higher-risk regions of Michigan are noted in the maps and tables at the end of this section. Personal and site vulnerabilities tend to vary by the engineering of each particular type of structure.

Impact on the Public

Tornadoes are rightfully dreaded as the most severe windstorms to which most of Michigan is vulnerable. Ordinary public activities must be curtailed in order to avoid extreme danger of injury and death either from the force of the winds themselves (which have the capacity to lift persons, heavy objects, or even structures and throw them great distances), or from the impact of objects that are being thrown forcefully around by the storm. Sheltering needs are compounded by the danger of broken and flying glass—to best ensure residents' safety, it is necessary to find the most secure area possible within a structure or affected area. An underground or specially reinforced, window-free room is usually required to guarantee personal safety (sometimes at considerable economic expense). The effects of a strong tornado may disrupt normal community functions for some time, or even cause a small community to be practically destroyed. Tornadoes cause more annual injuries, on average, than any other Michigan hazard except for structural fires.

Impact on Public Confidence in State Governance

When infrastructure failures occur, as from the impact of tornadic winds, a question may be raised about the adequacy of that infrastructure, its maintenance, and its design and regulation. For example, an assumption might be made by some that the burying of power lines should be undertaken (or required by legislation), even if it involves considerable expense, whereas a full consideration of the tradeoffs involved in such burial (e.g. greater difficulty in locating and repairing a broken line) may not have been considered. In events that require mass sheltering, such as schools or large gatherings (e.g. a county fair or community-sponsored event), the ability of local and state government to adequately plan for severe weather is often vital to the success of such events, which themselves are often important for various sectors of the local and state economy. Citizen discontent and media-exacerbated controversies have arisen from situations in which inadequate planning was evident, or provisions for public sheltering were inadequate.

Impact on Responders

Responders tend to be working outdoors in conditions from which most residents are taking shelter. Although special training and safety precautions have usually been taken (e.g. for line-repair workers), nevertheless, responders are more exposed to and at-risk from the impact of winds. Fortunately, tornado events tend to be

rather brief, but their unpredictability, and their difficulty of detection and avoidance, exacerbates the existing challenges involved in emergency response. Impeded traffic, power failures, debris, and road closures often make responses and the use of equipment much more difficult.

Impact on the Environment

Tornadoes are dangerous violent rotating columns of winds that can produce wind speeds from 73 to more than 300 miles per hour, and can cause severe environmental damage. Damage to the environment includes debris, fires, and chemicals from damaged and destroyed structures, vehicles, and infrastructure, which can be scattered for miles. Building materials, chemicals, smoke, sewage, and machinery can land in and cause harm to forests, valleys, streams, lakes, rivers, and wildlife species. Animals (including domesticated livestock) and other organisms can be killed or injured in the event of a tornado. Trees can easily be uprooted, branches broken off, and entire woodlands can be destroyed by tornado impacts. Rural settings can be damaged and plants can be carried to different parts of land for seeding where they otherwise would not have been. There is also an increased threat of fire in areas where dead trees are not removed in a timely matter.

The most dangerous type of environmental impact would be when a tornado strikes a facility that contains potentially hazardous or toxic materials, farm chemicals, trash in a local landfill, medical waste awaiting disposal, or radioactive materials. Not only can material be spread around the immediate site where the tornado strikes, a small (but important) fraction can be carried aloft and transported a great distance down streams or rivers. There is also a possibility that tornadoes can cause the spread of diseases, or fungi found in certain soils. Gas lines can also be ruptured and harm local air quality as well as cause environmental damage by seeping into the soil, rivers, lakes, and streams.

Climate Change Considerations

According to the National Oceanic and Atmospheric Administration, there is no known way to predict whether or how climate change is affecting thunderstorm and tornado frequency or severity. These types of weather events involve a different scale of phenomenon than climate change, and models of the latter have not yet been able to predict local trends in the former (http://www.spc.noaa.gov/faq/tornado/).

Significant Tornadoes in Michigan

May 25, 1896 – Oakland and Lapeer Counties

One of the mere handful of F5 intensity tornado events to be recorded in Michigan's state history, this event resulted in 47 deaths and 100 injuries, as the communities of Ortonville, Oakwood, and North Oxford suffered from the touchdown of this monstrous storm.

June 5, 1905 – Sanilac and Tuscola Counties

This was the second of Michigan's few recorded tornadoes that were measured as a full F5 intensity level. Five persons were killed and 40 were injured.

June 6, 1917 – Kalamazoo County

A deadly tornado struck the Climax and Cass Lake areas very hard, resulting in 4 deaths and 50 injuries.

March 28, 1920 – Genesee County

Another deadly tornado event, this time impacting Fenton and Flint most heavily, caused 14 deaths.

May 21, 1953 – St. Clair County

Two persons were killed, and 68 injured, as an F4 tornado left a path 10 miles long and 1 mile wide. The total damage was estimated at $2.5 million.

June 8, 1953 – Flint (Genesee County)

The June 8, 1953 Flint tornado, Michigan's worst storm to date (and classified as F5), is ranked 10th on the top ten list of single killer tornadoes that have occurred in the United States. It was also the last single tornado, until the May 2011 Joplin, MO EF5 tornado, to cause over 100 deaths in the U.S. The storm began its destructive path approximately two miles north of Flushing, moved east-northeast and devastated the north part of Flint before ending two miles north of Lapeer. The tornado obliterated homes on both sides of Coldwater Road for about one mile. It was there that most of the deaths occurred and the damage swath was over one-half mile wide. There were multiple deaths in at least 20 families. The final death toll stood at 115 in Flint alone, along with 785 injuries and total damage estimated at $19 million. Several tornadoes touched down in other locations in Michigan on that day as well, resulting in an additional six deaths and 129 injuries statewide.

April 3, 1956 – Hudsonville/Standale (Ottawa and Kent Counties)

In 1956, a category F5 tornado struck first at Hudsonville, then traveled northeast and plowed through both Ottawa and Kent Counties, killing 14 and injuring 200. (Some sources cite 17 deaths and 300 injuries.) Over 700 homes were destroyed. Numerous other tornadoes classified as F4 took their toll on other counties such as Manistee (2 killed, 24 injured), Grand Traverse, Benzie, and Allegan.

May 12, 1956 – Flint

Three persons were killed and 116 were injured as a result of an F4 tornado. On the same day, an F4 tornado also touched down in Wayne County, injuring 22 persons.

July 4, 1957 – Livingston and Oakland Counties

Six persons were injured in Livingston County, when F4 tornadic activity took place around the dinner hour. Oakland County was also impacted.

May 8, 1964 – Macomb County

Although numerous tornadoes occurred throughout the Lower Peninsula on this date, the worst impact was in Macomb County, where 11 persons were killed, 224 were injured, and an estimated $2.5 million in property damage was caused.

April 11, 1965 - Southern and Central Michigan

The April 11, 1965 Palm Sunday tornado outbreak, which affected many other states in the Midwest, had a particularly devastating impact on Michigan. As the following table indicates, a total of 23 tornadoes touched down in 14 southern and central Michigan counties, resulting in 53 fatalities, 798 injuries, and $51 million in damage to public and private property. Many of the tornadoes were rated F3 and F4 in intensity (strong and violent tornadoes), which undoubtedly contributed to the high death and injury tolls. Across the Midwest, this storm system spawned 47 confirmed tornadoes that collectively killed 271, injured 3400, and caused an estimated $200 million in property damage. In addition to Michigan, the other states that were affected by the storms included Indiana, Illinois, Ohio and Wisconsin. One of the tragic Michigan impacts was at Manitou Beach (Hillsdale-Lenawee County), where storms stuck a church with many persons inside.

April 11, 1965 (Palm Sunday) Tornado Outbreak: Michigan Impacts

County	Number of Tornadoes	Deaths	Injuries	Tornado Intensity
Allegan	1	1	9	F1
Barry	2	0	5	F1 and F3
Branch	2	18	400	F3 and F4
Clinton	1	1	8	F4
Gratiot	4	0	1	all F2
Hillsdale	2	6	94	F3 and F4
Kalamazoo	1	0	17	F3
Kent	1	5	142	F4
Lenawee	2	9	83	F3 and F4
Monroe	3	13	39	F3 and F4
Montcalm	1	0	0	F2
Ottawa	1	0	0	F4
Shiawassee	1	0	0	F4
Tuscola	1	0	0	F2
STATEWIDE TOTALS:	**23**	**53**	**798**	**2 F1 tornadoes; 6 F2 tornadoes; 6 F3 tornadoes; 9 F4 tornadoes**

Source: The Tornado Project / National Weather Service

April 21, 1967 – Southwestern and South-Central Lower Peninsula

Numerous twisters caused many injuries and extensive property damage across more than a dozen counties. Fortunately, there were no known fatalities, but NCDC records indicate a total of 51 persons injured and more than $28 million in property damage. A touchdown in Clinton County was of F4 intensity.

July 4, 1969 – Southeastern Michigan

Numerous tornado events marred the 1969 Independence Day holiday in Michigan. Although no fatalities were reported, 65 persons were injured across Jackson, Washtenaw, and Wayne Counties. Damage estimates exceeded $5 million.

April 3, 1974 – Southeastern Michigan

After a number of years without any Michigan fatalities from tornadoes, disaster struck full force in 1974. Two persons were killed and 43 injured when numerous tornadoes touched down in Monroe, Hillsdale, Lenawee, and other counties. Damages totaled nearly $3 million. Although a downward trend in fatalities and injuries had been observed in each decade since the 1950s, Michigan residents were again reminded about the deadly severity of its tornado hazard, and the sheer number of tornadoes was very large at this time. This date is also notable, nationally. National Weather Service data reports a total of 239 tornadoes across the United States on this day—8 of which were in Michigan, 16 in Ohio, and 54 in Indiana! Nationally, 308 persons were killed by tornado impacts on this single day, 5,416 were injured, and property damages amounted to $1.5 billion. This “super outbreak” broke records as being the largest number of tornadoes to strike the United States in a single day.

March 20, 1976 – Southeastern Michigan

Most of the Lower Peninsula’s residents were threatened by severe weather on this day, but as the dinner hour arrived in Oakland and Macomb Counties, a pair of tornadoes of F4 and F3 severity caused the weather impacts to turn deadly. Two persons were killed and 58 were injured. Nearly $26 million in property damage was also tabulated.

April 2, 1977 – Kalamazoo and Eaton Counties

Ten were injured in Kalamazoo, and then one person was killed and 44 injured in Eaton County. The tornado intensity was categorized as F4.

May 13, 1980 - Kalamazoo and Van Buren Counties

On May 13, 1980 two tornadoes occurred in southwest Michigan – one in Van Buren County and one in Kalamazoo. The Van Buren County tornado damaged over 500 structures and injured 15 persons. The Kalamazoo tornado damaged over 1,200 homes and caused five fatalities and 79 injuries. This was the greatest number of persons killed by a single tornado in Michigan since the April 11, 1965 occurrence. Damage in the two counties was so severe that a Presidential Major Disaster Declaration was granted to provide supplemental federal disaster assistance to those communities and individuals significantly affected by the storms. More than $50 million in damages were caused by these tornadoes.

July 4, 1986 – Menominee County

Another disastrous tornado event injured 12 and caused an estimated $2.5 million in property damage during the early evening on the Independence Day Holiday.

June 21, 1987 – Novi (Oakland County)

An F2 tornado caused 1 death, 6 injuries, and $250,000 in property damage.

October 4, 1990 - Genesee County

On October 4, 1990 an F2 intensity tornado touched down in Flint, Burton, and Davison Township in Genesee County, leaving a trail of destruction approximately 200 yards wide and four and one-half miles long. Over 30 homes and 20 businesses were severely damaged, and numerous roads and streets were blocked due to fallen trees and debris. One person was injured when his tractor-trailer was overturned by the strong winds while traveling on Interstate 69 in Burton. Total damage was estimated at $2 million. A Governor's Disaster Declaration was granted to provide supplemental state financial assistance to help pay for the cleanup costs associated with the storm.

March 27, 1991 – Entire Lower Peninsula

Severe weather events covered a wide area and produced numerous tornadoes across many Northern Lower Peninsula counties. Ogemaw, Iosco, and Alcona Counties were particularly hard-hit, and suffered a total of more than $5 million in property damage from F3 tornadoes that traveled dozens of miles. The Southern Lower Peninsula was also plagued by tornado impacts, including an F3 touchdown in Calhoun County that injured 18 persons, and an F3 tornado in Hillsdale County that caused $25 million in property damage.

April 16, 1992 - Plymouth (Wayne County)

On April 16, 1992 an F2 intensity tornado touched down in a mobile home park near Plymouth. The tornado destroyed 6 homes and damaged 14 others. Four residents of the mobile home park were injured. Total property damage was estimated at $2.5 million.

July 13, 1992 - Cass County

On July 13, 1992 an F2 intensity tornado touched down in northwest Cass County, leaving a trail of destruction one-half to one mile wide and six miles long. The tornado damaged or destroyed 40 homes, several agribusinesses, and one migrant labor camp. 25 persons were injured, and another 100 were left homeless by the tornado. Damage was estimated at $3.5 million, with nearly $2.7 million of that total being agricultural damage. A Governor's Disaster Declaration was granted to provide supplemental state assistance with security, sheltering and mass care.

July 2, 1997 - South-Central and Southeast Michigan

On July 2, 1997 a series of intense thunderstorms went through south-central and southeast Michigan. These storms spawned a total of 16 tornadoes, 13 of which occurred in the southeastern Michigan counties of Genesee, Lapeer, Livingston, Macomb, Oakland, Saginaw and Wayne. The total for southeast Michigan is the highest number for a single day since records have been kept from 1950. The tornadoes damaged or destroyed over 2,900 homes and nearly 200 businesses, and caused over $25 million in public damage and nearly $30 million in private damage. A total of 16 deaths were attributed to this storm front, but only 2 of those deaths were caused by the tornadoes. Another 120 persons were injured in the storm event (98 from tornadoes). The tornadoes and straight-line winds downed thousands of trees and power lines, which knocked out power to 350,000 electrical customers and caused significant public health and safety threats. Subsequent analysis by the National Weather Service indicated that the Wayne County tornado was F2 in intensity, while in Genesee County there were two F3 tornadoes and two F1 tornadoes. The remaining tornadoes were either F0 or F1 in intensity. A Presidential Major Disaster Declaration was granted for the five counties most severely impacted by the tornadoes and severe thunderstorms.

October 6, 1998 - Big Rapids (Mecosta County)

On October 6, 1998 a series of strong thunderstorms traveled through several counties in central Lower Michigan. The City of Big Rapids, in Mecosta County, was hardest hit by the storms. Officials from the National Weather Service determined that an "F-1 mini tornado," with winds reaching 80-90 miles per hour, had struck the Ferris State University campus, damaging several buildings and numerous surrounding residences and vehicles. The storm also downed trees and power lines in the area, and injured seven persons. The storm track was approximately 150 feet wide and one mile long. The storm dumped nearly 3 inches of rain in the Big Rapids area, flooding many streets and parking areas. In nearby Clare County, the storm destroyed one home, damaged ten others, and injured three persons.

July 3, 1999 - Comins (Oscoda County)

On July 3, 1999 a tornado touched down near Lewiston in Montmorency County and traveled southeast for twenty-one miles through Oscoda and Alcona Counties, causing damage to homes and businesses and injuring two persons. The hardest hit areas included the Village of Comins and Clinton Township in Oscoda County. The destruction was devastating – 80 percent of the Village of Comins was damaged or destroyed by the storm. Nine homes were destroyed, 46 homes sustained damage, and eight businesses were damaged or destroyed. The Clinton Township Hall and Fire Department buildings were also destroyed, and the Post Office sustained damage. Local roads were blocked by debris and downed power lines, leaving residents without power for several days. Only three buildings in town – a bar, a party store, and a senior center – were left standing intact. After striking Comins, the storm continued on its path and damaged another 20 residences at nearby Crooked Lake in Alcona County. A Governor's Disaster Declaration was granted to Oscoda County to provide supplemental state assistance with debris removal, clean up, and traffic control. Damage estimates approached $2 million.

May 21, 2001 - Southern and Central Michigan

On the afternoon of May 21, a line of severe thunderstorms moved across Michigan, spawning 21 tornadoes in 16 counties and causing damage in all but one of those counties. The hardest hit counties were Kalamazoo, Kent, Livingston and Oakland. Fortunately, no deaths or serious injuries occurred as a result of these storms. All totaled, the tornadoes caused about $5.5 million in property damage and $400,000 in agricultural crop damage. The largest share of the property damage – approximately $3 million – was caused by an F2 intensity tornado that struck Hartland and Tyrone Townships in Livingston County. The tornado tore through a golf course, destroying 12 vehicles and damaging 58 others, destroying 35 golf carts and a portion of the clubhouse, and injuring one person. The tornado also destroyed three nearby homes and two businesses, damaged another business, and downed hundreds of trees in the area. Several cars and semi-trailers were flipped and damaged when the tornado crossed U.S. 23.

September 9, 2001 - Delta Township (Eaton County)

In the late afternoon hours of September 9, 2001 an F1 intensity tornado carved an 8-mile long by 900-yard wide swath of destruction through Delta Township in Eaton County. The tornado – packing winds of up to 110 miles per hour – destroyed the cooling towers at a Lansing Board of Water and Light power plant, causing $4 million in damage and forcing the plant to shut down its operations. The tornado also destroyed a business and damaged several others in an industrial park, damaged dozens of homes and barns, and downed numerous trees and power lines. Even though the tornado crossed three Interstate Highways and passed several housing subdivisions along its path, it did not cause any deaths or serious injuries.

September 30, 2002 - Southeast Upper Peninsula

On September 30, 2002 a supercell produced three tornadoes and extensive downburst wind damage in southern Dickinson County. The majority of damage to the Iron Mountain, Kingsford and Quinnesec areas was caused by downburst winds, which knocked trees into homes, downed power lines, etc. The most significant damage was produced by the tornado that moved through Kingsford and Iron Mountain. An F1 intensity tornado developed in Florence County, Wisconsin and crossed the Menominee River just south of the Iron Mountain-Kingsford airport. Numerous trees and power lines were knocked down, blocking highway US-2 and disrupting electric power and telephone service. Gas lines were ruptured and several commercial buildings sustained substantial roof damage in Kingsford. Property damage due to all of the storms was estimated at around $7 million.

July 20, 2003 - Battle Creek (Calhoun County)

An F1 intensity tornado struck Calhoun County during the afternoon of July 20th, 2003. The tornado first touched down on the southeast side of Battle Creek. It lifted for several miles but eventually touched down again. It stayed on the ground for approximately three miles and intensified, causing a garage to be torn from a house and an older farm house to be rotated and pushed off its foundation. Three outbuildings and a barn were also destroyed. Roof shingle damage was also noted to other houses in the area. Hundreds of trees were uprooted or broken off. The tornado path was eight miles long from where it first touched down to where it lifted for the last time. The tornado width was nearly one half mile wide where the most severe damage occurred. The tornado caused nearly $1 million in property damage along with $200,000 in crop damage.

August 21, 2003 - Ingham County

On August 21, 2003 a tornado struck eastern Ingham County. The tornado's path length was 4.5 miles long and it was up to 1/2 mile wide. It was on the ground for 15 minutes and was rated as a lower F2 on the original Fujita scale. A severe thunderstorm warning was issued for Ingham County and that was soon upgraded to a tornado warning. Two homes were destroyed. One house collapsed and trapped two individuals inside, injuring both. At another location, a house was damaged and a barn was leveled, and a pickup truck was blown off the road. Tornado-related property damage was relatively low, but crop damage was estimated at $200,000.

August 24, 2007 – Eaton County

An EF3 tornado with wind speeds estimated at 140 mph produced its most severe damage along a path from M-50 just north of Kinsel Highway to just west of M-100 and Vermontville Highway near Potterville. A NWS storm survey indicated a tornado path which was 200 to 300 yards wide and 6.5 miles long. Fifteen homes were either destroyed or severely damaged. A roof was blown off a single-story home and windward-facing walls were blown in. The majority of the roof and garage from this home were not found. A roof was blown off a two-story home and the upper story front walls were blown in. Additional damage included the partial collapse of the upper story of a home, and another house was blown off its foundation. Two barns were destroyed and another incurred heavy damage just west of Potterville. Six persons were injured, and property damages totaled more than $25 million.

October 18, 2007 – Ingham County and Northern Lower Peninsula

A tornado occurred at night, and based on extensive damage to buildings and trees, it was classified EF2, with top winds estimated between 120 and 130 mph. The tornado began just northeast of Mason around 10:28 pm EDT and moved northeast at 40 to 45 mph through the City of Williamston between 10:40 and 10:45 pm. Approximately 100 structures were damaged in a subdivision on the south side of Williamston. Two fatalities occurred about 4 miles northeast of Williamston, where a modular home and its two occupants were flipped into a pond. The tornado then moved into Shiawassee County and dissipated shortly thereafter. Total property damages were estimated as nearly $20 million.

A historic tornado outbreak also rocked Northern Lower Michigan on the afternoon and evening of October 18, 2007. Northern Lower Michigan had a record six tornadoes on the day. The previous high was five, set on June 17, 1992. Unfortunately, a Kalkaska tornado produced a fatality. That was the first tornado fatality in Northern Lower Michigan since March 30 1976, when a single death had occurred in Ogemaw County.

June 6, 2010 – Monroe and Lenawee Counties

Two tornadoes struck Monroe County, one classified as EF2 and the other as EF1. The stronger tornado was up to 800 yards wide and tracked 13 miles across Monroe County, including movement through the Village of Dundee, which was the hardest-hit location (after which the tornado weakened to EF0 levels in its east-southeastern course). The weaker tornado was up to 500 yards wide and tracked 5 miles from the Woodland Beach area to the northeast, reaching Estral Beach and proceeding out into Lake Erie. The weaker tornado was especially significant for two reasons—it caused some damage at the Fermi nuclear power facility, and it also impacted an area that is a project site for flood mitigation activities (at Estral Beach). The tornado damaged more than 125 homes and 23 vehicles, and set back a significant amount of flood mitigation project work in the area. Estimated damages from the weaker tornado amounted to $10 million. Estimated damages from the stronger tornado were $50 million. A total of 311 buildings were damaged in Monroe County, and 5 houses were destroyed. A weaker F1 tornado also caused $500,000 in damage to property in adjacent Lenawee County.

June 27, 2010 – St. Clair County

Among the tornado damages this day was a disastrous strike at a campground just north of I-69 and west of Wadhams Road in Clyde Township. One person was killed and four were injured. The tornado was classified as EF1, with winds up to 95 mph. About 10 campers were damaged or destroyed, including being blown into the water of a large pond nearby. Total damages at that location were estimated at $700,000. Total tornado damages that day amounted to more than $1.25 million.

April 26, 2011 – Allegan County

An EF-0 tornado (with winds peaking near 85 mph) damaged buildings from the Deboer Turkey Farm to trailers near Burnips (Allegan County). The tornado tore a small section of roof off a warehouse building, knocked over several trailers, and blew the windows out of several cars, then uplifted and collapsed an approximately 100-foot section of pole-barn. The roof was torn off about a 50-foot section of another barn. To the northeast, several small outbuildings were destroyed and trees were uprooted. Several houses received minor roof, soffit, and garage door damaged. The tornado lifted after partially destroying a 75 year-old barn. The property damage totaled approximately $1M.

May 29, 2011 – Calhoun County

Three tornados produced wind gusts up to 100mph in the southern Lower Peninsula, resulting in several uprooted trees and downed power lines. 163,000 homes and businesses were without power. The Battle Creek area was hit the hardest, with straight line winds between 75 and 100mph, causing wide-spread damage. The event resulted in a Governor's disaster declaration for Calhoun County, no deaths or serious injuries were reported.

March 15, 2012 – Southeast Michigan (Washtenaw, Lapeer

Three tornadoes resulted in a total of $12M in property damage. Fortunately, there were no reported deaths or injuries. An EF-3 tornado touched down near Dexter (Washtenaw County), with maximum wind speeds of 135-140 mph. The tornado damaged at least 200 homes (20 severely), and destroyed two more. An EF2 tornado (with maximum wind speeds of around 125mph) struck approximately 5 miles northwest of Lapeer, leaving a damage path roughly 4.6 miles long with a maximum width of 400 yards. Damage included a destroyed garage, a house shifted off its foundation, uprooted trees and other minor structural damage. An EF0 tornado with maximum wind speeds of 85mph was confirmed in central Monroe County, near Yargerville. The estimated path length of this tornado was 0.5, miles with a maximum width of 50 yards. The damage consisted of siding and shingles blown off a house, a tipped car, a shed destroyed, and trees blown down.

Other Recent Significant Tornado Outbreaks of General Interest in the United States

April 2011 – National Outbreak

April 2011 shattered the previous April tornado record of 267 tornadoes set in April 1974 by producing 677 confirmed tornadoes (875 were reported) across the United States. The previous record for any month was 552 tornadoes in May of 2003. In particular, from April 25-28, 2011 there were 362 tornadoes, breaking the previous single tornado outbreak record of 148 tornadoes on April 3-4, 1974. The 361 people killed during the April 2011 outbreak set a new record, with 322 of those deaths occurring during the April 25-28, 2011 time frame alone. There were four EF5 tornadoes during this particular outbreak. The biggest loss of life for a single tornado occurred in Tuscaloosa-Birmingham, Alabama, with at least 65 fatalities. This tornado, rated an EF5, had a maximum width of 1.5 miles and a track 80 miles long. Although the numbers with this single tornado are impressive, the deadliest single tornado on record in the United States still is the Tri-State tornado (Mo., Ill., Ind.) on March 18, 1925, when 695 died.

May 2011 – Joplin, MO

One month after the April 2011 national outbreak occurred, another deadly single tornado occurred in Joplin, Missouri, resulting in 158 fatalities and 990 injuries on May 22, 2011. This Joplin, Missouri tornado is only the second EF5 tornado to occur in Missouri since 1950. The tornado resulted in being the costliest disaster in Missouri history, at over $2.8 billion.

May 2013 – Oklahoma

An EF5 tornado swept across the southern part of the Oklahoma City metropolitan area, destroying many structures along a 17 mile-long path that was more than 1 mile wide and most strongly hit the city of Moore, OK. According to http://www.srh.noaa.gov/oun/?n=tornadodata-okc-table, 24 deaths, including 7 children when a school wall collapsed, and more than 300 destroyed homes resulted. On the previous day, an EF4 tornado had struck nearby Norman, OK, killing two persons. Widespread media coverage took place as these events happened.

Programs and Initiatives

Note: Many of the programs and initiatives designed to mitigate, prepare for, respond to, and recover from severe straight-line winds have the dual purpose of also protecting against tornadoes. As a result, there is some overlap in the narrative programs and initiatives descriptions for each respective hazard. This redundancy allows each hazard section to stand alone, eliminating the need to refer to other hazard sections for basic information.

National Weather Service Doppler Radar

The National Weather Service has completed a major modernization program designed to improve the quality and reliability of weather forecasting. The keystone of this improvement is Doppler Weather Surveillance Radar, which can more easily detect severe weather events that threaten life and property – including tornadoes and the severe storms that spawn them. Most important, the lead time and specificity of warnings for severe weather have improved significantly.

Doppler technology calculates both the speed and the direction of motion of severe storms. By providing data on the wind patterns within developing storms, the new system allows forecasters to better identify the conditions leading to severe weather such as tornadoes and severe thunderstorms. This means early detection of the precursors to severe storms, as well as information on the direction and speed of storms once they form.

National Weather Service Watches/Warnings

The National Weather Service issues tornado watches for areas when the meteorological conditions are conducive to the development of a tornado. People in the watch area are instructed to stay tuned to NOAA weather radio and local radio or television stations for weather updates, and watch for developing storms. Once a tornado has been sighted and its existence is confirmed and reported, or Doppler Radar shows strong probability of the development or occurrence of a tornado, the National Weather Service will issue a tornado warning. The warning will identify where the tornado was sighted, the direction in which it is moving, and the time frame during which the tornado is expected to be in the area. Persons in the warning area are instructed to seek shelter immediately.

The State and local government agencies are warned via the Law Enforcement Information Network (LEIN), National Oceanic and Atmospheric Administration (NOAA) weather radio, and the Emergency Managers Weather Information Network (EMWIN). Public warning is provided through the Emergency Alert System (EAS). The National Weather Service stations in Michigan transmit information directly to radio and television stations, which in turn pass the warning on to the public. The National Weather Service also provides detailed warning information on the Internet at www.weather.gov, where an interactive map can be used.

Public Warning Systems

Numerous communities in Michigan have outdoor warning siren systems in place to warn the public about impending tornadoes and other hazards. Most of these systems were originally purchased to warn residents of a nuclear attack, but that purpose was expanded to include severe weather hazards as well. These systems can be very effective at saving lives in densely populated areas where the siren warning tone is most audible. In more sparsely populated areas where warning sirens are not as effective, communities are turning to NOAA weather alert warning systems to supplement or supplant outdoor warning siren systems. Unfortunately, a large number of communities across the state do not have adequate public warning systems in place to warn their residents of severe weather or other hazards. Federal funding specifically allocated to assist communities in the purchase of public warning systems has effectively disappeared, leaving many communities unable to purchase adequate systems to warn their residents of impending danger.

Attempting to fill some of that funding void, the State of Michigan has used federal Hazard Mitigation Grant Program (HMGP) funds to assist local communities in purchasing public warning systems. To date, HMGP funds have been used to purchase and install more than 80 outdoor warning sirens, over 1,000 NOAA weather alert monitors for schools, hospitals and places of public assembly, four NOAA weather radio transmitters, and several other early warning systems. Communities that received funding for these projects were encouraged to implement a warning education program to ensure that residents know what to do once they receive warning of an impending hazardous event. Because HMGP funds must be used to fund a wide variety of mitigation projects, the amount of funds available to fund warning systems is limited to a small percentage of the overall available grant funds allocated to the state. The HMGP funds are provided on a 75% federal, 25% local cost share. A Presidential major disaster declaration is required to activate the HMGP funding. As a result, the funding stream may not always be available in the future. In addition, state mitigation priorities may change over time, putting public warning systems at a lower priority than other mitigation projects. However, the HMGP does provide at least one possible avenue for assisting communities in enhancing their local public warning capability.

Severe Weather Awareness Week

Each spring, the Emergency Management and Homeland Security Division, Department of State Police, in conjunction with the Michigan Committee for Severe Weather Awareness, sponsors Severe Weather Awareness Week. This annual public information and education campaign focuses on severe weather events such as tornadoes, thunderstorms, lightning, hail, high winds and flooding. The purpose of the tornado portion of this campaign is to inform the public about what tornadoes are and when they usually occur, what they should do if a tornado occurs, what community warning systems exist, and to provide other pertinent tornado-related information as appropriate. Informational materials are disseminated to schools, hospitals, nursing homes, other interested community groups and facilities, and the general public. Special educational programs are often conducted during this week.

Manufactured Home Anchoring

Manufactured homes are vulnerable to tornado damage if they are not properly anchored down. As a result, a major national effort has been initiated to encourage structural anchoring or “tie down” of manufactured homes. The Michigan Manufactured Housing Commission Administrative Rules (R 125.1602, Subsection 5) require new manufactured home installations in floodplains to be structurally anchored to a foundation. Through this requirement, the possibility of damage from wind is minimized. Although this will not protect a manufactured home from a direct hit by a tornado, it certainly will help prevent rollovers in most high-wind situations. Unfortunately, structures outside designated floodplains do not have to comply with the anchoring provision, although many owners choose to comply voluntarily. It should also be noted that local communities have the option of adopting an ordinance that requires anchoring of manufactured home installations located outside a designated floodplain. State anchoring system standards are outlined in Administrative Rules R 125.1605 through R 125.1608.

FEMA Safe Room Benefit-Cost Calculator

An advanced way for a community to analyze the tornado risk for various structures in its part of the state would be to make use of FEMA's 2000 computer model, "Benefit Cost Analysis of Hazard Mitigation Projects: Tornado and Hurricane Shelter Model." This program takes into consideration building information such as area, length, width, and location in the state, to determine whether or not a mitigation project involving reinforced "safe rooms" will provide adequate protection during a tornado for building occupants. Although this program does not specify exact risk of tornado damage for each community, it does provide an approximating regional model to follow for communities considering building tornado "safe rooms" to mitigate tornado deaths and injuries. If your community wants to know more about the feasibility of the "safe rooms," the model is available through the MSP/EMHSD office. Important Note: Only counties with greater tornado risks should inquire about the FEMA computer model, as the model does not work well for counties with very few tornado occurrences. Additionally, FEMA provides a disclaimer on the model that states that the results from the benefit-cost analysis are not conclusive or positively cost-effective—and that modeled projects are NOT guaranteed for potential government grants. For more information about safe rooms, refer to http://www.fema.gov/safe-rooms.

Electrical Infrastructure Reliability

One of the major problems associated with the severe winds from tornadoes and thunderstorms is the loss of electric power caused by trees falling on power lines. Michigan has had numerous widespread and severe electrical power outages caused by severe wind and other weather events. Several of those outages have resulted in upwards of 500,000 electrical customers (more than 5% of the State's population) being without power for several hours to several days at a time. Wind-related damage to electric power facilities and systems is a concern that is being actively addressed by utility companies across the state. Detroit Edison, Consumers Energy and other major electric utility companies have active, ongoing programs to improve system reliability and protect facilities from damage by tornadoes, severe straight-line winds, and other hazards. Typically, these programs focus on trimming trees to prevent encroachment of overhead lines, strengthening vulnerable system components, protecting equipment from lightning strikes, and placing new distribution lines underground. The Michigan Public Service Commission (MPSC) monitors power system reliability to help minimize the scope and duration of power outages.

Structural Bracing and Wind Engineering

One of the best ways to protect buildings from damage from severe winds associated with thunderstorms, tornadoes, or other high wind events is to install structural bracing and metal connectors (commonly called hurricane clips) at critical points of connection in the frame of the structure. Typically, this involves adding extra gable end bracing at each end of the structure, anchoring the roof rafters to the walls with metal connector straps, and properly anchoring the walls and sill plate to the foundation. This extra bracing helps ensure that the roof stays on the structure, and the structure stays anchored on its foundation. Experience in tornadoes and other high wind events has shown that once the roof begins to peel away from the walls, or the building begins to move off its foundation due to extreme lateral wind forces, major structural damage occurs. If the damage continues unabated, the building can end up being a total loss.

Urban Forestry and Tree Maintenance Programs

Urban forestry programs can be very effective in minimizing storm damage caused by falling trees or tree branches. In almost every tornado or other severe wind event, falling trees and branches cause power outages and clog public roadways with debris. However, a properly designed, managed and implemented urban forestry program can help keep tree-related damage and impact to a minimum. To be most effective, an urban forestry program should address tree maintenance in a comprehensive manner, from proper tree selection, to proper placement, to proper tree trimming and long-term care.

Every power company in Michigan has a tree trimming program, and numerous local communities have some type of tree maintenance program. The electrical utility tree trimming programs are aimed at preventing encroachment of trees and tree limbs within power line rights-of-way. Typically, professional tree management

companies and utility work crews perform the trimming operations. At the local government level, only a handful of Michigan communities have actual urban forestry departments or agencies. Rather, crews from the public works agency or county road commission perform the bulk of the tree trimming work.

When proper pruning methods are employed, and when the work is done on a regular basis with the aim of reducing potential storm-related damage, these programs can be quite effective. Often, however, tree trimming work is deferred when budgets get tight or other work is deemed a higher priority. When that occurs, the problem usually manifests itself in greater storm-related tree debris management problems down the line. Although nothing will prevent tree damage from a direct tornado strike, a well-planned, well-managed urban forestry program can certainly reduce the scope and magnitude of the post-tornado tree debris problem.

Hazard Mitigation Alternatives for Tornadoes

- Increased coverage and use of NOAA Weather Radio.
- Public early warning systems and networks.
- Tree trimming and maintenance to prevent limb breakage and safeguard nearby utility lines. (Ideal: Establishment of a community forestry program with a main goal of creating and maintaining a disaster-resistant landscape in public rights-of-way.)
- Buried/protected power and utility lines. (NOTE: Where appropriate. Burial may cause additional problems and costs in case of breakage, due to the increased difficulty in locating and repairing the problem.)
- Using appropriate wind engineering measures and construction techniques (e.g. structural bracing, straps and clips, anchor bolts, laminated or impact-resistant glass, reinforced entry and garage doors, window shutters, waterproof adhesive sealing strips, and interlocking roof shingles) to strengthen public and private structures against severe wind damage.
- Proper anchoring of manufactured homes and exterior structures such as carports and porches.
- Securing loose materials, yard, and patio items indoors or where winds cannot blow them about.
- Construction of concrete safe rooms in homes and shelter areas in mobile home parks, fairgrounds, shopping malls, or other vulnerable public areas.

Tie-in with Local Hazard Mitigation Planning

Because many means of implementing mitigation actions occur through local activities, this updated MHMP places additional emphasis on the coordination of State-level planning and initiatives with those taking place at the local level. This takes two forms:

1. The provision of guidance, encouragement, and incentives to local governments by the State, to promote local plan development, and
2. The consideration of information contained in local hazard mitigation plans when developing State plans and mitigation priorities.

Regarding the first type of State-local planning coordination, MSP guidance has included the "Local Hazard Mitigation Planning Workbook" (EMD-PUB 207), which is currently being updated for release by 2015. For the second type of State-local planning coordination, a section later in this plan summarizes hazard priority information as it has been reported in local hazard mitigation plans. Here, it will merely be noted that tornadoes were identified as one of the most significant hazards in local hazard mitigation plans for the following counties: Antrim, Arenac, Berrien, Calhoun, Clare, Dickinson, Eaton, Genesee, Gratiot, Hillsdale, Huron, Ingham, Jackson, Kent, Livingston, Mackinac, Macomb, Mecosta, Midland, Monroe, Montcalm, Oakland, Osceola, Ottawa, Saginaw, Van Buren, Washtenaw, and Wayne.

Tornado History for Michigan Counties – arranged by region – Jan. 1996 to Oct. 2013
(The Lower Peninsula regions are ordered by "tiers" from south to north, west to east)
Please refer to the Michigan Profile Map section for an explanation of regional divisions

COUNTY or area	Tornado Events	Days with Tornadoes	Tot. property damage	Tot. crop damage	Injuries	Deaths
Washtenaw	5	5	$12,595,000			
Wayne	3	3	$90,750,000		90	
.Livingston	8	7	$10,220,000		3	
Oakland	6	6	$6,917,000			1
Macomb	4	3	$30,800,000		6	
5 Co Metro region	**5.2 avg.**	**4.8 avg.**	**$151,282,000**		**99**	**1**
Berrien	7	6	$2,110,000			
Cass	6	5	$5,900,000			
St. Joseph	6	4	$822,200		1	
Branch	2	2	$50,000			
Hillsdale	3	3	$351,000			
Lenawee	4	4	$580,000			
Monroe	7	6	$60,203,000		11	
.Van Buren	4	3	$110,000	$10,000		
Kalamazoo	7	6	$690,500	$142,000		
Calhoun	4	4	$3,200,000	$275,000		
Jackson	2	2	$700,000	$50,000		
.Allegan	7	7	$1,602,000			
Barry	2	2	$300,000			
Eaton	8	8	$50,357,000	$225,000	6	
Ingham	7	7	$20,850,000	$200,000	2	2
.Ottawa	3	3	$250,000	$10,000		
Kent	7	4	$570,000	$30,000		
Ionia	2	2	$110,000	$55,000		
Clinton	2	2	$450,000	$150,000		
Shiawassee	9	7	$655,000		1	
Genesee	18	10	$18,510,000		2	1
Lapeer	9	9	$1,880,000			
St. Clair	7	7	$895,000		4	1
.Muskegon	3	3	$50,000			
Montcalm	2	2	$152,000	$25,000		
Gratiot	5	3	$675,000	$29,000	1	
Saginaw	13	9	$6,308,000	$5,500		
Tuscola	8	7	$1,060,000		1	
Sanilac	5	5	$445,000			
.Mecosta	1	1	$1,200,000		12	
Isabella	5	5	$715,000	$10,000	1	
Midland	3	3	$225,000			
Bay	4	4	$170,000			
Huron	5	5	$415,000		1	
34 Co S Lower Pen	**5.5 avg.**	**4.7 avg.**	**$182,560,700**	**$1,216,500**	**43**	**4**

Continued on next page…

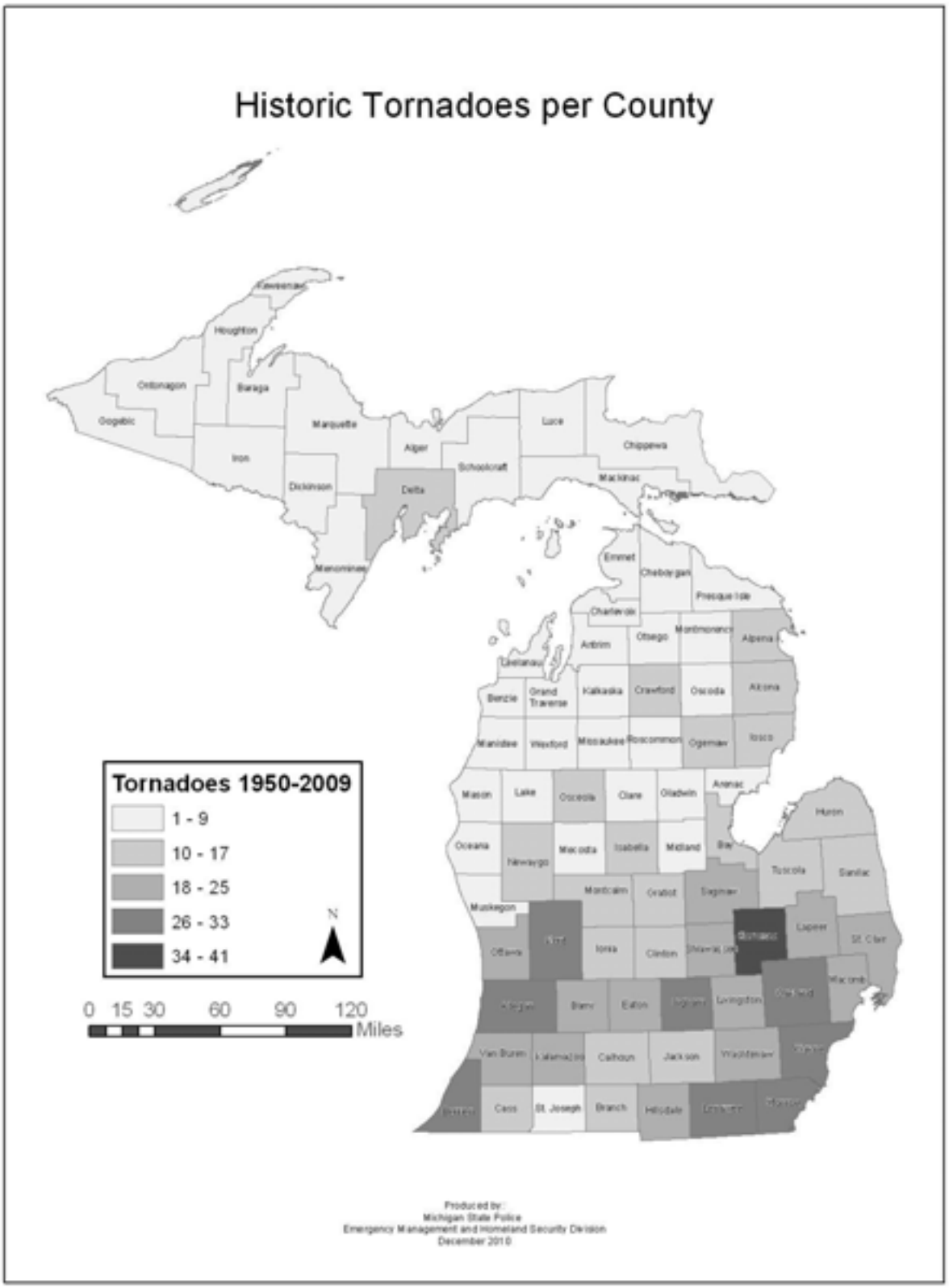
Part 2 of Michigan County Tornado Events table

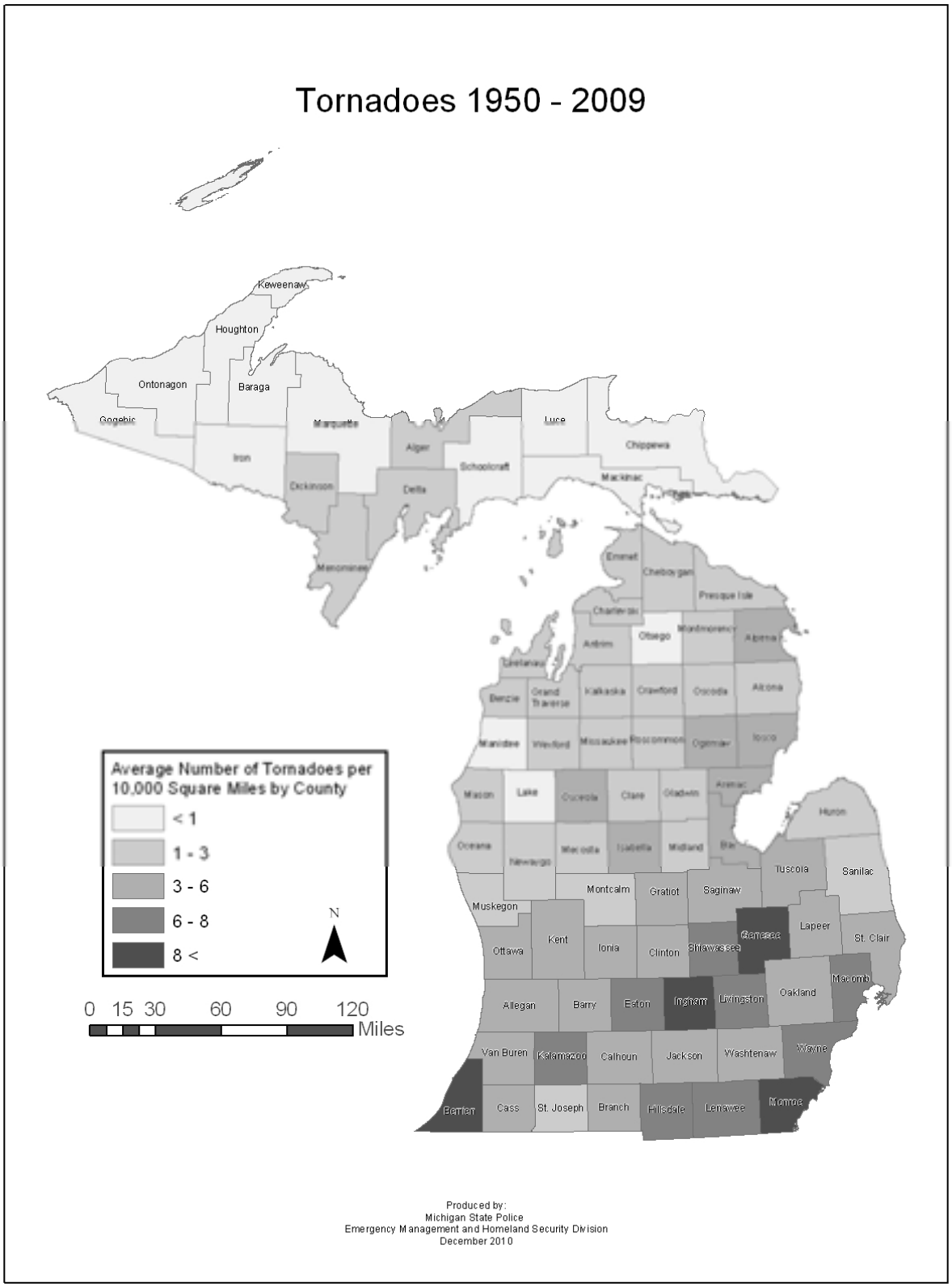
.Oceana						
Newaygo	4	4	$62,000	$10,000		
.Mason	1	1				
Lake	1	1	$150,000	$50,000		
Osceola	5	5	$512,000	$100,000	1	
Clare	3	3	$210,000	$10,000		
Gladwin	2	2	$90,000			
Arenac	3	3	$15,000	$1,000	1	
.Manistee	1	1	$15,000			
Wexford	1	1	$8,000			
Missaukee	1	1				
Roscommon						
Ogemaw	2	2	$75,000			
Iosco	1	1	$75,000			
.Benzie						
Grand Traverse						
Kalkaska	3	3	$1,100,000		1	1
Crawford	4	4	$60,000			
Oscoda	4	3	$2,890,000		2	
Alcona	3	3	$315,000			
.Leelanau	1	1	$20,000			
Antrim	2	2	$4,000			
Otsego	1	1	$11,000			
Montmorency	3	3	$210,000			
Alpena	4	3	$491,000			
.Charlevoix	1	1				
Emmet	1	1				
Cheboygan	2	2	$30,000			
Presque Isle	2	2				
29 Co N Lower Pn	**1.9 avg.**	**1.8 avg.**	**$6,343,000**	**$172,000**	**5**	**1**
Gogebic	1	1	$25,000			
Iron	1	1	$15,000			
Ontonagon	1	1	$20,000			
Houghton						
Keweenaw	1	1				
Baraga						
.Marquette	4	4	$10,000	$5,000		
Dickinson	6	3	$7,013,000	$120,000		
Menominee	2	2	$25,000			
Delta	4	4	$38,000			
Schoolcraft						
Alger	1	1				
.Luce	1	1				
Mackinac	1	1				
Chippewa	1	1	$200,000			
15 Co Upp.Pen	**1.6 avg.**	**1.5 avg.**	**$7,346,000**	**$125,000**		
MICHIGAN TOTAL	**292**	**127**	**$347,332,000**	**$1,512,000**	**147**	**6**

Number of Tornadoes in Michigan, by County: 1950-2009

County (A-K)	Tornadoes: 1950-2009	County (L-Z)	Tornadoes: 1950-2009
Alcona	11	**Lake**	2
Alger	6	**Lapeer**	20
Allegan	26	**Leelanau**	3
Alpena	14	**Lenawee**	31
Antrim	9	**Livingston**	24
Arenac	7	**Luce**	2
Baraga	2	**Mackinac**	5
Barry	18	**Macomb**	18
Bay	12	**Manistee**	2
Benzie	4	**Marquette**	6
Berrien	28	**Mason**	5
Branch	15	**Mecosta**	9
Calhoun	15	**Menominee**	7
Cass	14	**Midland**	8
Charlevoix	4	**Missaukee**	8
Cheboygan	6	**Monroe**	28
Chippewa	6	**Montcalm**	11
Clare	8	**Montmorency**	6
Clinton	17	**Muskegon**	7
Crawford	10	**Newaygo**	12
Delta	11	**Oakland**	31
Dickinson	7	**Oceana**	5
Eaton	25	**Ogemaw**	14
Emmet	5	**Ontonagon**	2
Genesee	41	**Osceola**	16
Gladwin	9	**Oscoda**	5
Gogebic	3	**Otsego**	3
Gd. Traverse	4	**Ottawa**	18
Gratiot	12	**Presque Isle**	6
Hillsdale	23	**Roscommon**	8
Houghton	1	**Saginaw**	21
Huron	12	**Sanilac**	14
Ingham	27	**Schoolcraft**	3
Ionia	17	**Shiawassee**	25
Iosco	11	**St. Clair**	20
Iron	5	**St. Joseph**	9
Isabella	13	**Tuscola**	17
Jackson	17	**Van Buren**	18
Kalamazoo	25	**Washtenaw**	24
Kalkaska	7	**Wayne**	28
Kent	31	**Wexford**	7
Keweenaw	2	**STATEWIDE:**	**923**

IMPORTANT NOTE: Tornadoes that crossed county lines are counted more than once in this table. Therefore, the statewide total is less than the sum of the individual county totals.
Source: National Weather Service


Historic Tornadoes per County
Tornadoes 1950-2009
1 - 9
10 - 17
18 - 25
26 - 33
34 - 41
N
0 15 30 60 90 120
Miles
Produced by:
Michigan State Police
Emergency Management and Homeland Security Division
December 2010



Tornado Frequency, by land area (per 10,000 square miles)

Comparative National Tornado Statistics

Source: National Weather Service

Annual Average Number of Strong-Violent (F2-F5) Tornadoes by State

* Theses maps use data for the years 1950 to 2009 for the State of Michigan only, but the rest of the states show data only for the years 1950 to 1995. Although updated national maps were not available from the National Weather Service for use in this plan, new information for Michigan was readily provided upon request, and these maps were then revised by MSP/EMHSD staff to reflect this new data

Average Annual Number of Strong-Violent (F2-F5) Tornadoes per 10,000 Square Miles by State

Michigan State Police
Emergency Management & Homeland Security Division
January 2011

Extreme Temperatures

Prolonged periods of very high or very low temperatures, often accompanied by other extreme meteorological conditions.

Hazard Description

Temperature extremes are broken down into two categories: extreme heat and extreme cold. Both extremes can last for weeks, without any advance warning and in the middle of a seemingly normal weather pattern. Additionally, both extreme heat and extreme cold can cause loss of life to vulnerable populations, damage to infrastructure, and disruptions to schools and businesses.

Extreme cold is primarily associated with the wintery months of November through March and categorized by temperatures plunging near or below 0°F. Extreme heat occurs mainly during the summer months of June, July, and August and is marked by temperatures above 90°F.

Although all counties in Michigan are susceptible to harsh subfreezing temperatures, counties in the North Central and Upper Peninsula of the state typically have more annual days of extreme cold than the southern portions of Michigan. Periods of extreme cold are risky for those in both rural and in urban areas. Frostbite and hypothermia is common in rural areas where people are trapped outdoors and do not adjust properly to the temperatures. Even indoors, hypothermia is a concern for individuals living in inadequately heated apartments or rooms. Loss of life can occur with either of these situations. Damage to buildings and pipelines can also occur in bitter cold conditions, resulting in expensive repairs and potential days of business and school shutdowns.

Counties in the southern half of the state have the highest frequency of days exhibiting extreme heat. Urban areas are especially prone to days with soaring temperatures, with concrete and asphalt surfaces reflecting sunlight, air pollutants trapping heat, and lessened circulation of air through densely-developed areas. Individuals working outdoors, the elderly, and children need to be accounted for during oppressively sizzling conditions, as they are most at risk for heat exhaustion, and fatal heat stroke. Scorching weather also puts a strain on the energy demands for an area, as air conditioning becomes a necessity for vulnerable populations. Possible shutdowns of schools, colleges, and industries can occur during these times.

Prolonged periods of extreme temperatures, whether extreme summer heat or extreme winter cold, can pose severe and life-threatening problems for Michigan's citizens. Although they differ in their initiating conditions, the two hazards share a commonality in that they both tend to have a special impact on the most vulnerable segments of the population—the elderly, young children and infants, impoverished individuals, and persons who are in poor health. Due to their different characteristics, extreme summer heat and extreme winter cold hazards will mostly be discussed separately in this section. For both types of temperature extremes, however, a longer hot or cold spell makes the temperature effects much more severe on vulnerable populations—a longer duration tends to produce more severe effects.

Hazard Analysis

Extreme Summer Heat is characterized by a combination of very high temperatures and humid conditions. When persisting over a long period of time, this phenomenon is commonly called a heat wave. The major threats of extreme summer heat are heat exhaustion and heatstroke (a major medical emergency). **Heat exhaustion** is a less severe condition than heatstroke, but it causes problems involving dizziness, weakness and fatigue. Heat exhaustion is often the result of fluid imbalance due to increased perspiration in response to the intense heat. Treatment generally consists of restoring fluids and staying indoors in a cooler environment until the body returns to normal. If heat exhaustion is not addressed and treated, it can advance to heatstroke, so medical attention should be sought immediately.

Heatstroke symptoms include a high body temperature (it can be 106 degrees or higher), dry skin, inadequate perspiration, paleness or reddening, confusion or irritability, and seizures. The victim may become delirious, stuporous, unconscious, or even comatose. Cooling is essential to preventing permanent neurological damage or death. Other, less serious risks associated with extreme summer heat are often exercise-related and include **heat cramps** (an imbalance of fluids that occurs when people unaccustomed to heat exercise outdoors) and **heat syncope** (a loss of consciousness by persons not acclimated to hot weather). Periods of hot weather also entail risks of dehydration, even for those who are not engaged in demanding physical activities. Non-caffeinated fluids should be consumed to maintain adequate hydration.

A useful set of general principles to recognize is that evaporation is a cooling mechanism for our bodies. Evaporation of moisture (i.e. perspiration) doesn't occur as rapidly when the surrounding air already has a relatively high moisture content (humidity). Thus, humidity inhibits evaporation and produces a feeling of greater heat, while winds assist the evaporation of perspiration from skin and thus tend to produce a feeling of greater coolness. It can therefore be difficult for the body to precisely gauge actual outdoor temperatures—it rather senses the potential for heat gain or loss. A period of extreme heat is more debilitating when the air humidity is high, and a period of extreme cold is similarly more dangerous when coupled with strong winds. For these reasons, temperature alone is usually only a limited indicator of the weather's likely threat to human health, and additional factors should also be considered. The additional factors of humidity and wind speed have provided the basis for two additional means of describing the extent of extreme temperatures' impact—the **Heat Index** (HI) and the **Wind Chill Temperature Index** (WCT).

The following tables indicate the way that temperature, humidity, and wind speed probably feels to the human body, and suggest the types of temperature effects relevant to Michigan's climate. Although some of the resulting heat numbers may at first seem outrageous to describe Michigan temperatures, some of the extremes are actually comparable to what is felt in a sauna, which is often set at more than 140 degrees. Like saunas, such heat should not be felt by the body for more than brief periods of time, and since one of the body's cooling reactions is to increase the rate of blood circulation, this also adds to the burden placed on the heart muscle, and can be too much strain for some persons to bear.

HEAT INDEX	**Actual Temperature (degrees Fahrenheit)**									
Rel. Humidity	**90**	**92**	**94**	**96**	**98**	**100**	**102**	**104**	**106**	**108**
40%	91	94	97	101	105	109	114	119	124	130
45%	92	96	100	104	109	114	119	124	130	137
50%	95	99	103	108	113	118	124	131	137	144
55%	97	101	106	112	117	124	130	137	145	
60%	100	105	110	116	123	129	137	145		
65%	103	108	114	121	128	136	144			
70%	106	112	119	126	134	143				
75%	109	116	124	132	141					
80%	113	121	129	138						
85%	117	126	135	145						
90%	122	131	141							
95%	127	137								

Source: formulas obtained from the National Climatic Data Center

TECHNICAL NOTE: The two indices can also be summarized by the following mathematical formulas, in which T means temperature (in degrees Fahrenheit), H means relative humidity (%), W means wind speed (in miles per hour), and E denotes a shorthand for scientific notation (times 10 raised to the power of the number that follows the E):

$$HI = -42.38 + 2.049T + 10.14H - 0.2248HT - (6.838E\text{-}3)T^2 - (5.482E\text{-}2)H^2 + (1.229E\text{-}3)HT^2 + (8.528E\text{-}4)H^2T - (1.99E\text{-}6)H^2T^2$$

$$WCT = 35.74 + 0.6215T - 35.75(W^{0.16}) + 0.4275T(W^{0.16})$$

WIND CHILL	Actual Temperature (degrees Fahrenheit)									
Wind speed (mph)	**40**	**30**	**20**	**10**	**0**	**-10**	**-20**	**-30**	**-40**	**-50**
5	36	25	13	1	-11	-22	-34	-46	-57	-69
10	34	21	9	-4	-16	-28	-41	-53	-66	-78
15	32	19	6	-7	-19	-32	-45	-58	-71	-83
20	30	17	4	-9	-22	-35	-48	-61	-74	-88
25	29	16	3	-11	-24	-37	-51	-64	-78	-91
30	28	15	1	-12	-26	-39	-53	-67	-80	-94
35	28	14	0	-14	-27	-41	-55	-69	-82	-96
40	27	13	-1	-15	-29	-43	-57	-71	-84	-98
45	26	12	-2	-16	-30	-44	-58	-72	-86	-100
50	26	12	-3	-17	-31	-45	-60	-74	-88	-102
55	25	11	-3	-18	-32	-46	-61	-75	-89	-104
60	25	10	-4	-19	-33	-48	-62	-76	-91	-105

Other tables and calculators can be found online, such as the tables for a heat index at http://www.ncdc.noaa.gov/oa/climate/conversion/heatindexchart.html, or the tables and calculator for wind chill at http://www.nws.noaa.gov/om/windchill/.

Although these indices involve a fairly straightforward means of expressing the "feel" of the weather in terms of a temperature equivalent, conditions for each individual will still vary with the duration and type of weather exposure, personal health, extent of acclimation, and the type of clothing worn. For example, exposure to full sunshine can increase heat index values by up to 15%. Also, cooler air holds less moisture, and dryer air readily allows the cooling evaporation of perspiration from skin. In other words, the heat index and wind chill index only involve a consideration of two important factors, but they are still more useful than a consideration of temperature alone. The Heat Index table assumes shady conditions with a light wind. Actual indoor conditions may vary, trapping heat and/or humidity in some locations and making them potentially much more dangerous. Prolonged exposure, physical activity, and age all tend to increase the risks associated with heat. Conditions that might cause heat cramps in a teenager could be experienced as heat exhaustion by a middle-aged person, and as heat stroke by a senior citizen. Young infants, however, are also vulnerable to heat effects.

Extremely high numbers are not shown in the table, since there are limits on the extent to which both humidity and heat would be experienced as a part of Michigan's weather (shown on the map below). However, the following guidelines are recommended, to make better use of the raw numbers:

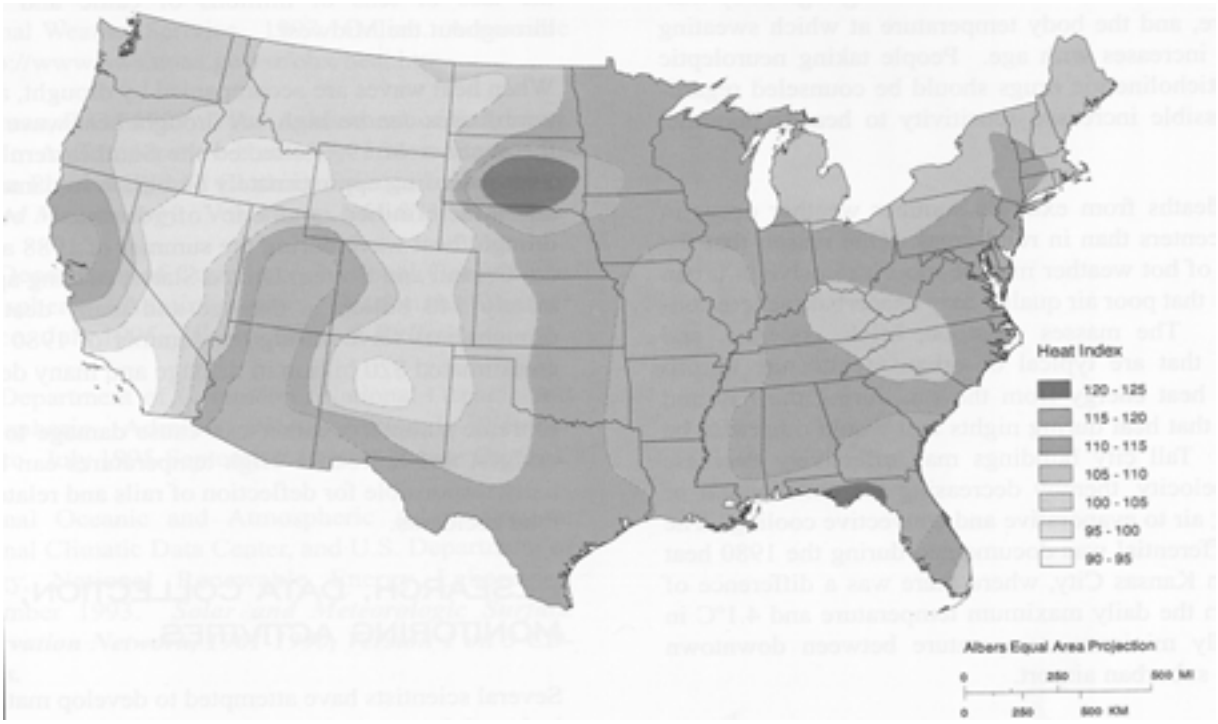
Heat Index above 130 degrees:
Extreme Danger (Heat stroke or sunstroke is highly likely with prolonged exposure and/or physical activity)

Heat Index in the 105 to 129 degree range:
Danger (Sunstroke, muscle cramps, heat exhaustion is likely with prolonged exposure and physical activity)

Heat Index in the 90 to 104 degree range:
Extreme Caution (Sunstroke, muscle cramps and/or heat exhaustion possible with prolonged exposure/activity)

Heat Index up through 89 degrees:
Caution (Fatigue possible with prolonged exposure and/or physical activity)

Severity and Extent of Extreme Summer Heat in the United States



Source: U.S. Department of Commerce; *Multi-Hazard Identification and Risk Assessment*, 1999, FEMA

Extreme Heat History for Michigan Counties – arranged by region – Jan. 1996 to Oct. 2013
(The Lower Peninsula regions are ordered by "tiers" from south to north, west to east)
Please refer to the Michigan Profile Map section for an explanation of regional divisions

COUNTY or area	Extreme Heat Events	Days with Extreme Heat	Injuries	Deaths
Washtenaw	12	12	17	
Wayne	14	14	541	3
.Livingston	12	12	4	
Oakland	15	15	194	5
Macomb	13	13	60	
5 Co Metro region	**13 avg.**	**13 avg.**	**816**	**8**
Berrien				
Cass				
St. Joseph				
Branch				
Hillsdale				
Lenawee	12	12	2	
Monroe	12	12	2	
.Van Buren				
Kalamazoo				
Calhoun				
Jackson				
.Allegan				
Barry				
Eaton				
Ingham				
.Ottawa				
Kent				
Ionia				
Clinton				
Shiawassee	11	11	5	
Genesee	9	9	23	
Lapeer	11	11	1	
St. Clair	11	11	7	
.Muskegon				
Montcalm				
Gratiot				
Saginaw	11	11	19	
Tuscola	11	11	1	
Sanilac	10	10	1	
.Mecosta				
Isabella				
Midland	11	11	3	
Bay	11	11	1	
Huron	10	10	1	
34 Co S Lower Pen	**3.8 avg.**	**3.8 avg.**	**66**	

Continued on next page…

Part 2 of Michigan County Extreme Heat History Table

.Oceana				
Newaygo				
.Mason				
Lake				
Osceola				
Clare				
Gladwin	1	1		
Arenac	1	1		
.Manistee	1	1		
Wexford	1	1		
Missaukee	1	1		
Roscommon	1	1		
Ogemaw	1	1		
Iosco	1	1		
.Benzie	1	1		
Grand Traverse	1	1		
Kalkaska	1	1		
Crawford	1	1		
Oscoda	1	1		
Alcona	1	1		
.Leelanau	1	1		
Antrim	1	1		
Otsego	1	1		
Montmorency	1	1		
Alpena	1	1		
.Charlevoix	1	1		
Emmet	1	1		
Cheboygan	1	1		
Presque Isle	1	1		
29 Co N Lower Pn	**0.8 avg.**	**0.8 avg.**		
Gogebic	1	1		
Iron	1	1		
Ontonagon	1	1		
Houghton				
Keweenaw	1	1		
Baraga	1	1		
.Marquette	1	1		
Dickinson	1	1		
Menominee	1	1		
Delta				
Schoolcraft				
Alger	1	1		
.Luce				
Mackinac	1	1		
Chippewa	1	1		
15 Co Upp.Pen	**0.7 avg.**	**0.7 avg.**		
MICHIGAN TOT.	**234**	**18**	**882**	**8**

In Michigan, heat advisories will tend to be announced when the heat index is calculated to exceed 105 degrees in an area for a period of at least 3 hours in duration. It should be noted, however, that the temperature inside of vehicles without air conditioning can be dozens of degrees hotter than the outdoor temperature—an outdoor temperature might be "only" 100 degrees Fahrenheit, but people may then get into a car that exceeds 130 degrees. People vary in the conditions in which they operate (and in their capacity to tolerate extreme temperatures), and can find themselves in circumstances that threaten their health even if no official temperature advisory has been issued.

Heat waves tend to have stagnant atmospheric conditions that trap pollutants in urban areas and thus compound the health effects faced by urban residents. Because the combined effects of high temperatures, high humidity, and trapped pollution are focused more intensely in urban centers, heatstroke and heat exhaustion are a greater problem in sizeable cities than in suburban or rural areas. Nationwide, approximately 135 deaths per year are attributable to extreme heat (a total of 3,311 over the 24 year period from 1986 to 2009, according to http://www.nws.noaa.gov/om/hazstats/images/70-years.pdf). Extreme summer heat is also hazardous to livestock and agricultural crops, and it can cause water shortages, exacerbate fire hazards, and prompt excessive demands for energy. Roads, bridges, railroad tracks and other infrastructure are susceptible to damage from extreme heat (due to the effects of thermal expansion of materials). Scorching weather also puts a strain on the energy demands for an area, as the use of air conditioning increases greatly. Possible shutdowns of schools, colleges, and industries can occur during these times.

Air conditioning is probably the most effective measure for mitigating the effects of extreme summer heat on people. Unfortunately, many of those most vulnerable to this hazard do not live or work in air-conditioned environments, especially in major urban centers where the vulnerability is highest. The use of fans to move air may help some persons feel more comfortable, but when the temperature reaches the high 90s, fans will not prevent heat-related illness. Bathing with cool water is more effective, but moving to a cooler environment (a basement or air-conditioned location) is most effective—even if only for a few hours per day.

To mitigate the extreme heat of summer, communities should have a contingency plan in place to protect those people who are most vulnerable to the heat. These contingency plans should include: setting up "cooling stations" where people can go to get out of the heat; a hierarchy of closings for industries, businesses, and schools during shutdown periods; and a means of explaining the dangers of heat conditions, such as pamphlets and local broadcast and print media. Monitoring of dangerous conditions can also be done through the National Weather Service website. A risk assessment should calculate the likelihood of such incidents and the number of days of extreme temperatures likely to be experienced in your community each year. It should also take account of past losses and harm caused by such events, and determine who or what is still vulnerable to such conditions today.

Heat waves severe enough to threaten health do not occur every year, and several relatively mild summers may intervene between major heat waves. The problem is complicated by the fact that long-term weather forecasts cannot reliably predict prolonged periods of extreme summer heat. Short-term forecasts of hot weather are more accurate, but often leave little time for mobilizing to effectively combat the hazard. Nevertheless, planning and preparedness activities can occur to mitigate the effects of this weather hazard.

Because of its geographic location in relation to the Great Lakes, Michigan is somewhat less susceptible to prolonged periods of extreme hot temperatures than are many other states. However, the Upper Midwest, in which Michigan is located, is definitely vulnerable to extreme temperature events. As a result, Michigan communities (and particularly urban centers) must always be prepared to respond to heat events in an organized, coordinated and expedient manner. Extreme summer heat poses the greatest danger to urban residents—especially the elderly, children, outdoor laborers, people with poor health, and people residing in homes without air conditioning. Michigan's urban communities must address extreme summer heat in their emergency preparedness efforts. Human service agencies, voluntary organizations, health departments, medical and health care facilities, and schools may have a role in response to a heat wave. The Michigan Department of Community

Health, together with local health departments, medical and health care facilities, may have to establish specialized medical surge facilities to assist in the care of a large number of persons who may be affected in such events. In addition, the local media could be tapped to assist in information dissemination and community outreach efforts.

In an average year, Michigan has many days above 90° Fahrenheit. MDCH and NWS estimate about 5 deaths per year, on average, due to extreme heat. Although larger cities have been noted as having more risk from extreme heat, it should also be noted that residents in isolated rural locations may have trouble accessing air-conditioned places, or reaching designated cooling shelters. Such access may be easier for urban residents.

Extreme Winter Cold periods can, like heat waves, result in a significant number of temperature-related deaths. Each year in the United States, approximately 700 persons die as a result of severe cold temperature-related causes. This is substantially higher than the average of 175 heat-related deaths each year. It should be noted that a significant number of cold-related deaths are not the direct result of "freezing" conditions. Rather, many deaths are the result of illnesses and diseases that are negatively impacted by severe cold weather, such as stroke, heart disease and pneumonia. It could convincingly be argued that, were it not for the extreme cold temperatures, death would not have occurred at the time that it did due to the illness or disease alone. There are, in various parts of Michigan, an average of between 3 and 50 (or more) days per year at or below 0° Fahrenheit. Michigan also tends to have between 90 and 180 (or more) days per year in which the temperature is below the freezing point.

Hypothermia (the unintentional lowering of core body temperature), and **frostbite** (damage from tissue being frozen) are probably the two conditions most closely associated with cold temperature-related injury and death. Hypothermia is usually the result of over-exposure to the cold, and is generally thought to be clinically significant when core body temperature reaches 95 degrees or less. As body temperature drops, the victim may slip in and out of consciousness, and appear confused or disoriented. Treatment normally involves warming the victim (preferably performed by trained medical personnel) but frostbitten areas should not be rubbed. Although frostbite damage itself rarely results in death (which may occur due to hypothermia instead), in extreme cases it can result in the amputation of the affected body tissue.

Periods of extreme cold are risky for those in both rural and in urban areas. Frostbite and hypothermia is common in rural areas where people are trapped outdoors and do not adjust properly to the temperatures. Even indoors, hypothermia is a concern for individuals living in inadequately heated apartments or rooms. Loss of life can occur with either of these situations. Damage to buildings and pipelines can also occur in bitter cold conditions, resulting in expensive repairs and potential days of business and school shutdowns.

To mitigate the effects of the unfavorable cold temperatures, communities should make sure that housing codes are appropriate and that adequate furnaces are in place in apartment dwellings. Inspections of vulnerable and outdated infrastructure should be made in the fall season, before winter sets in. In addition, proper insulation of piped areas can prevent water main breaks.

In the wind chill chart, extremely low apparent temperatures can also be associated with an amount of exposure time that it takes to cause frostbite. Cells of the table that have darker shadings denote wind chill temperatures that can produce frostbite in 10 minutes or less. Cells with lighter shadings are associated with frostbite times of 30 minutes or less. Unshaded cells in the table should require longer exposure times to cause frostbite. Again, the chart displays only two factors that contribute heavily to risk, but risk can be increased for an individual in particular circumstances. For example, people should be aware that the drier air (common to winter weather) also allows a more rapid drop in temperature than is the case with warm summer air. As a cold front moves in, or as daytime high temperatures for the day change to nighttime low temperatures, the corresponding drop in temperature can be much greater when the humidity is low. Persons who are outdoors can rapidly find themselves in danger of hypothermia.

Extreme Cold History for Michigan Counties – arranged by region – Jan. 1996 to Oct. 2013
(The Lower Peninsula regions are ordered by "tiers" from south to north, west to east)
Please refer to the Michigan Profile Map section for an explanation of regional divisions

COUNTY or area	Extreme Cold Events	Days with Extreme Cold	Tot. property damage	Tot. crop damage	Injuries	Deaths
Washtenaw	9	9	$500,000		10	
Wayne	16	15	$275,000		34	9
.Livingston	7	7	$25,000		10	
Oakland	8	8	$25,000		14	4
Macomb	9	9	$25,000		11	3
5 Co Metro region	**9.8 avg.**	**9.6 avg.**	**$850,000**		**79**	**16**
Berrien						
Cass						
St. Joseph						
Branch						
Hillsdale						
Lenawee	9	9	$1,025,000		10	
Monroe	9	9	$25,000		10	
.Van Buren						
Kalamazoo						
Calhoun						
Jackson						
.Allegan						
Barry						
Eaton						
Ingham						
.Ottawa						
Kent	1	1	$150,000			
Ionia						
Clinton						
Shiawassee	6	6	$25,000		10	
Genesee	7	7	$25,000		11	
Lapeer	6	6	$25,000		10	
St. Clair	6	6	$25,000		10	
.Muskegon						
Montcalm	1	1		$100,000		
Gratiot						
Saginaw	7	7	$525,000		10	
Tuscola	6	6	$25,000		10	
Sanilac	7	7	$25,000		10	1
.Mecosta						
Isabella						
Midland	6	6	$25,000		10	
Bay	7	7	$25,000		10	2
Huron	6	6	$25,000		10	
34 Co S Lower Pen	**84 avg.**	**84 avg.**	**$1,950,000**	**$100,000**	**121**	**3**

Continued on next page…

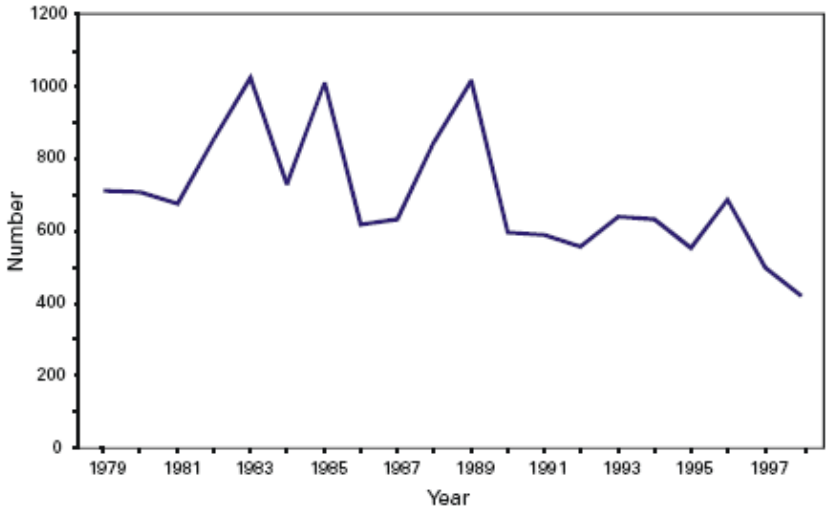
Part 2 of Michigan County Extreme Cold History Table

.Oceana	1	1		$2,000,000		
Newaygo						
.Mason						
Lake						
Osceola						
Clare						
Gladwin	1	1				
Arenac	1	1				
.Manistee	1	1				
Wexford	1	1				
Missaukee	1	1				
Roscommon	1	1				
Ogemaw	1	1				
Iosco	1	1				
.Benzie	1	1				
Grand Traverse	2	1				
Kalkaska	2	1				
Crawford	1	1				
Oscoda	1	1				
Alcona	1	1				
.Leelanau	2	2				1
Antrim	1	1				
Otsego	1	1				
Montmorency	1	1				
Alpena	1	1				
.Charlevoix	1	1				
Emmet	1	1				
Cheboygan	1	1				
Presque Isle	1	1				
29 Co N Lower Pn	**0.93 avg**	**0.86 avg.**		**$2,000,000**		**1**
Gogebic	19	19				
Iron	18	18				1
Ontonagon	13	13				
Houghton						
Keweenaw	6	6				
Baraga	16	16				
.Marquette	16	16				
Dickinson	17	17				
Menominee	13	13				
Delta	11	11				
Schoolcraft	10	10				
Alger	5	5				
.Luce	3	3				
Mackinac	1	1				
Chippewa	2	2				
15 Co Upp.Pen	**10 avg.**	**10 avg.**				**1**
MICHIGAN TOTAL	**325**	**56**	**$2,800,000**	**$2,100,000**	**200**	**21**

Hypothermia usually occurs in one of two sets of circumstances. One situation involves hypothermia associated with prolonged exposure to cold while participating in outdoor sports such as skiing, hiking or camping. Most victims of this form of hypothermia tend to be young, generally healthy individuals who may lack experience in dealing with extreme cold temperatures. The second situation involves a particularly vulnerable person who is subjected to only a moderate, indoor cold stress. A common example would be that of an elderly person living in an inadequately heated home. In such circumstances, hypothermia may not occur until days or perhaps weeks after the cold stress begins. Isolated rural locations may involve difficulties in reaching a heated space, or a designated warming shelter.

Deaths due to extreme winter cold are often not associated with a particular weather event. Rather, they are the result of a one-time over-exposure to severe cold weather (a hiker lost in the woods, or car failure in a rural area), or more commonly from continuous exposure to moderate cold temperatures by vulnerable persons (such as the elderly). In some cases, hypothermia deaths can be linked to severe winter weather such as snowstorms or blizzards, where the victim is caught unprepared for the extreme cold temperatures. As mentioned earlier, many cold temperature-related deaths involve the exacerbation of an existing, serious medical condition such as heart disease or pneumonia. In Michigan, approximately 70% of weather-related fatalities (about 40 deaths per year) are attributed to exposure to the cold (according to the Michigan Department of Community Health and the National Weather Service). The following 20-year table gives an indicator for the nation as a whole.

Number of Hypothermia-Related Deaths in U.S.: 1979-1998



Source: CDC Morbidity and Mortality Weekly Report

The special vulnerability of elderly persons to hypothermia has become apparent. Over half of the hundreds who die each year due to cold exposure are 60 years of age or older, even though this age group only represents about 20% of the country's population. This remarkable statistic may be due, in part, to an impaired perception of cold as well as the voluntarily setting of thermostats to relatively low temperatures. In addition, high energy costs and the relative poverty among some elderly people may discourage their setting thermostats high enough to maintain adequate warmth (just as it may cause others to limit their use of fans and air conditioning during summer heat waves). Because many elderly people live alone and do not have regular visitors, the cold conditions may persist for several days or weeks, thus allowing hypothermia to set in.

Babies and very young children are also very vulnerable to hypothermia. In addition, statistics indicate that death due to cold is more frequent among males than females in virtually all age groups. Part of that may be explained by differences in risk factors, and part may be due to different rates of cold exposure between activities performed by different sexes. Cold weather also increases blood viscosity, narrows small blood vessels, and increases blood pressure, all of which increase the risk of cardiovascular problems (e.g. a heart attack).

As explained in the general introduction to the weather hazards section of this plan, there should be no presumption made that temperatures will automatically be higher or lower in a southern or northern part of the state, despite the existence of certain trends and correlations. All parts of Michigan experience temperature extremes that threaten health. In fact, Michigan's two most extreme temperatures on record did not occur either in the extreme north of the Upper Peninsula or at the extreme south of the Lower Peninsula, but rather at locations in between – in the Northern part of the Lower Peninsula. The record low temperature of -51 was measured at Vanderbilt (located in Otsego County) and the record high of 112 was at Mio (located in Oscoda County).

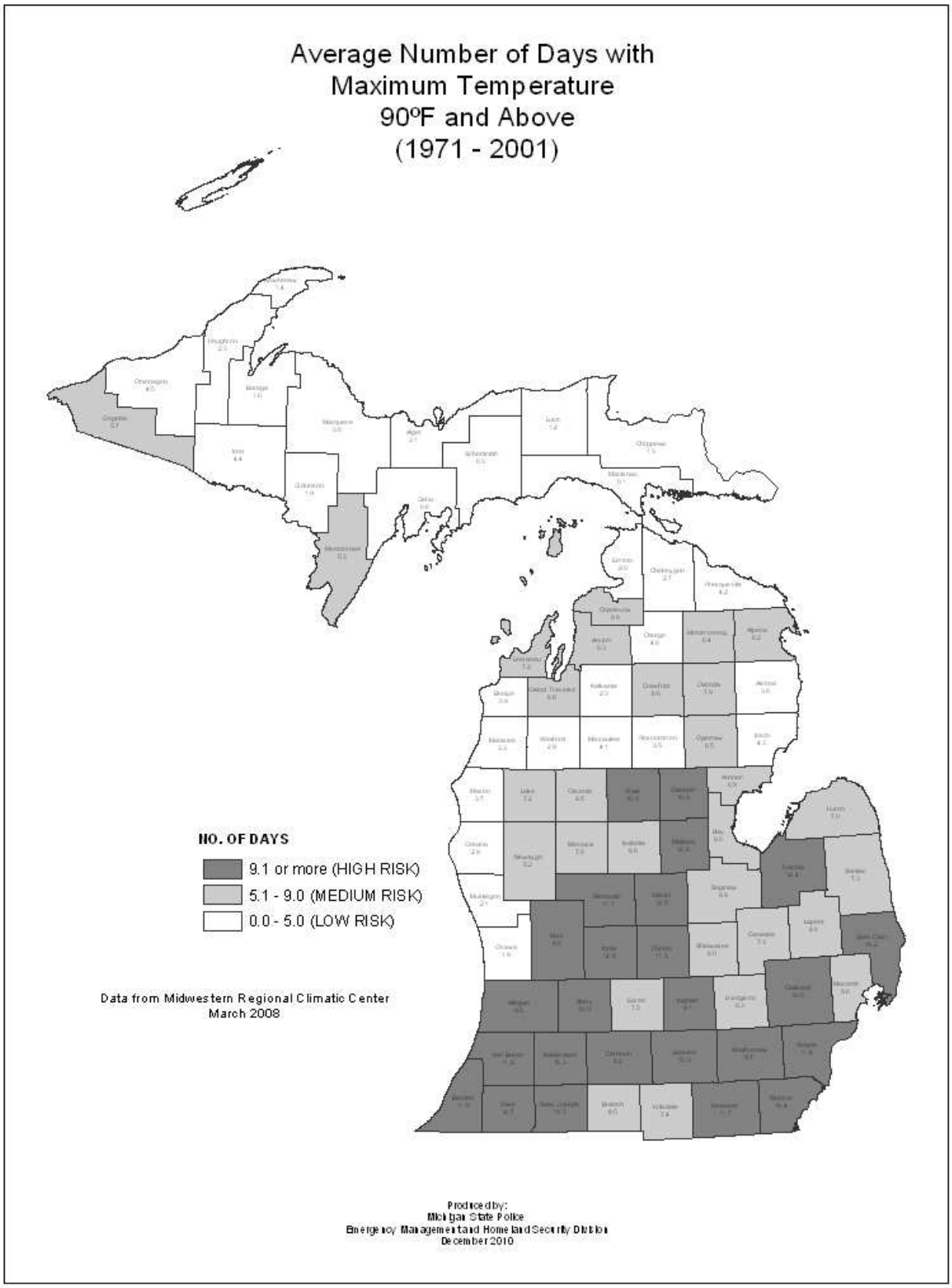
Nevertheless, there is some variation across Michigan in the conditions under which wind chill advisories are issued, since it is the case that the warm season is longer in the southern part of the Lower Peninsula and there is a different phase of that area's population becoming acclimated to each year's winter weather. For southern Michigan, wind chill advisories tend to be issued when the Wind Chill Temperature is within the -15 to -24 range. In northern Michigan and the Upper Peninsula, advisories tend to be issued when the WCT is within the -20 to -29 range. Wind chill warnings tend to be issued when the WCT gets down to -25 or below, in southern Michigan, or when it gets down to -30 or below, in northern Michigan.

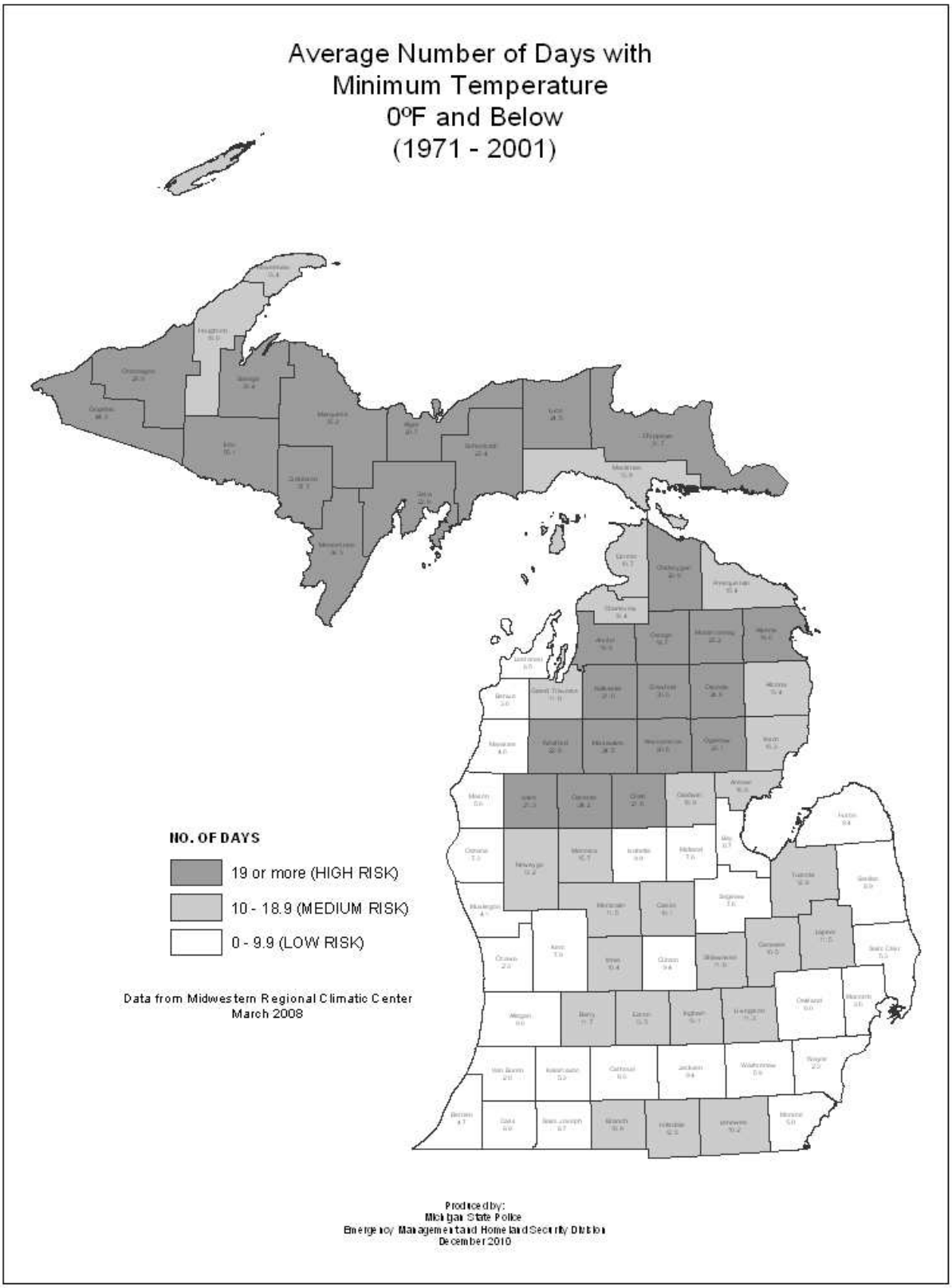
Maps on the following two pages illustrate the average number of days above 90 degrees and the average number of days below zero degrees, Fahrenheit. Although they are based on the three decades from 1971 to 2001, they give an excellent indication of the "typical" annual risk and exposure to Michigan summer and winter temperature extremes, for all of Michigan's counties.

A different type of risk indicator is provided in the subsequent table that lists record low and high temperatures for numerous weather stations across Michigan. For convenience, the listings are divided into three regions: the Southern Lower Peninsula, Northern Lower Peninsula, and Upper Peninsula. Note that these records are for specific stations, and do not necessarily represent all-time records for the counties or surrounding localities in that area. They should instead be taken as an indicator of the extremes to which various specific locations have experienced, across the state.

As already noted in the Introduction to the Weather Hazards section of this plan, although it makes sense to think in terms of three general Michigan regions for an analysis of trends and weather patterns, the extreme temperature hazard must be understood to be a significant one in every part of the state. This is true of both summer and winter temperature extremes. In general, however, "seasons" can be defined for these three regions, to denote when there is a serious risk of extreme temperature events. These "seasons" are based upon the historical occurrence of very high temperatures (above 90 degrees) and very low temperatures (near zero degrees, or below) and will here be generally defined:

	Extreme Heat Risk Season	**Extreme Cold Risk Season**
Southern Lower Peninsula	Early May to late September	Late November to early April
Northern Lower Peninsula	Late May to late September	Early November to April
Upper Peninsula	Late May to early September	Late September to May


Average Number of Days with
Maximum Temperature
90ºF and Above
(1971 - 2001)
NO. OF DAYS
9.1 or more (HIGH RISK)
5.1 - 9.0 (MEDIUM RISK)
0.0 - 5.0 (LOW RISK)
Data from Midwestern Regional Climatic Center
March 2008
Produced by:
Michigan State Police
Emergency Management and Homeland Security Division
December 2010


Average Number of Days with
Minimum Temperature
0ºF and Below
(1971 - 2001)
NO. OF DAYS
19 or more (HIGH RISK)
10 - 18.9 (MEDIUM RISK)
0 - 9.9 (LOW RISK)
Data from Midwestern Regional Climatic Center
March 2008
Produced by:
Michigan State Police
Emergency Management and Homeland Security Division
December 2010

Historic Temperature Records at Various Michigan Locations

Southern Lower Peninsula	Record Low Temperature	Record High Temperature
Adrian (Lenawee County)	-26° (Jan. 20)	108° (July 14 & 24)
Benton Harbor (Berrien County)	-21° (Jan. 12)	104° (June 1, July 21 & 30)
Coldwater (Branch County)	-23° (Jan. 4)	108° (July 24)
Ann Arbor (Washtenaw County)	-23° (Feb. 11)	105° (July 24)
Bloomingdale (Van Buren Co.)	-23° (Feb. 3)	105° (July 5 & 13)
Detroit (Wayne County)	-24° (Dec. 22)	105° (July 24)
Jackson (Jackson County)	-21° (Feb. 10)	105° (July 14)
Pontiac (Oakland County)	-22° (Feb. 5)	104° (July 6, 8, 16, 24)
Flint (Genesee County)	-25° (Jan. 18)	108° (July 8, 13)
Grand Rapids (Kent County)	-24° (Feb. 13 & 14)	108° (July 13)
Port Huron (St. Clair County)	-19° (Jan. 19)	103° (July 9)
Harbor Beach (Huron County)	-22° (Feb. 9)	105° (July 10)
Big Rapids (Mecosta County)	-36° (Feb. 11)	103° (July 13, 14 & 30)

The counties listed above start with the southernmost tier in Michigan, and proceed generally northward, tier by tier. Big Rapids is situated on the very edge of the southern and northern regions, and its record low fits the northern region.

Northern Lower Peninsula	Record Low Temperature	Record High Temperature
Alpena (Alpena County)	-37° (Feb. 17)	106° (July 13)
East Tawas (Iosco County)	-29° (Feb. 1 & 20)	106° (July 8 & 9)
Gaylord (Otsego County)	-39° (Jan. 6)	101° (July 11 & 30)
Gladwin (Gladwin County)	-39° (Feb. 20)	105° (July 13)
Traverse City	-37° (Feb. 17)	105° (July 7)
Upper Peninsula	**Record Low Temperature**	**Record High Temperature**
Hancock (Houghton County)	-30° (Feb. 9 & 10)	102° (July 7)
Ironwood (Gogebic County)	-41° (Jan. 17, Feb. 12)	104° (July 13)
Munising (Alger County)	-33° (Feb. 25)	103° (July 7, 8, 9, Aug. 6)
Sault Ste. Marie (Chippewa Co.)	-37° (Feb. 8 & 10)	98° (July 3, 30, Aug 5, 6)
Statewide all-time records	-51° (Feb. 9) Vanderbilt (Otsego County)	112° (July 13) Mio (Oscoda Co.)

Source: Extreme Michigan Weather, by Paul Gross (2010, University of Michigan Press, Ann Arbor)

These tables show all the record low and high temperatures at various weather stations across Michigan. It can be noted that the majority of record low temperatures occurred in January and February, and the majority of record high temperatures took place in July. This pattern holds true across all of Michigan's regions. It should also be noted that lower-lying areas often experience colder temperatures, since colder air is denser and heavier and thus tends to sink to lower areas. Local variations of that type help to explain why the absolute coldest and hottest temperature extremes ever recorded in Michigan are more extreme than the various records listed for specific weather stations.

The tempering effects of the Great Lakes also help moderate the impact of the severe cold weather normally prevalent in the Midwest during the winter months. Even so, Michigan still endures many days of extremely cold temperatures in an average winter, and prolonged periods of extreme cold are not uncommon during the months of January and February. During those months especially, increased outreach to elderly persons - particularly those living alone - is certainly warranted. In addition, communities should be particularly cognizant of the vulnerability of elderly as well as very young persons when power outages occur due to ice and snowstorms. When outages are expected to last for several hours or more, consideration should be given to opening warming

shelters. Once power is restored, outreach to the elderly may be necessary to ensure that furnaces have been re-started and are working properly.

Extreme cold temperatures are a universal hazard in Michigan. Whereas heat waves tend to impact urban centers more than suburban or rural areas, cold temperatures are an "equal opportunity" killer. Every community in Michigan is vulnerable, regardless of location or size. It must also be noted that many of the agricultural sectors of Michigan are vulnerable to crop losses because of extreme cold events. A couple of severe recent events have involved unusually warm temperatures, which plant life may treat as a return of Spring, followed by a re-freeze when the plants have made themselves more vulnerable and which can therefore be devastating to them.

Impact on the Public
Extreme temperatures can have direct impacts on personal health and productivity, which may collectively lead to reductions in economic activity and travel (e.g. tourism, shopping). Extreme temperature events tend to cause greater energy use, which can involve not only higher energy costs but can also result in infrastructure failures due to limitations in the capacity of the utility system. About 900 annual deaths nationwide have been attributed to extreme temperatures (mostly from extreme cold, involved in about 700 deaths), ranking this hazard as the second leading cause of fatalities (behind structural fires).

Impact on Public Confidence in State Governance
Questions may arise about the amount of utility assistance, provision/promotion of heating/cooling centers, etc. that governments are meant to provide, and whether there are identifiable and unjustified inequities in the extent and quality of resources and infrastructure provided to different groups and locations throughout the state. Inequities might be attributed to shortcomings in government efficacy and intentions, rather than to limited resources and the historical aspects of differential development patterns.

Impact on Responders
Heat and freezing conditions may directly impact the health and effectiveness of responders, including the potential for dealing with impacts on overwhelmed or failed infrastructure. Special clothing and equipment (and maintenance) tends to become necessary under conditions of extreme cold. Frozen pipes may inhibit or limit responders' access to water that is needed to fight fires, and extra activities and caution may be needed around wintry fire zones where water may have frozen and made footing treacherous for emergency workers (and others).

Impact on the Environment
Periods of extreme heat or cold can affect the environment in several ways. When the temperature rises, power consumption increases, as households and public buildings require more energy to run air conditioning. Agricultural areas also use more pumped water as irrigation is increased. More coal is burned to fulfill the rising demand and thus, more greenhouse gases and toxins are released into the air.

Long-term environmental damage includes greenhouse gas emissions that cause the earth's temperature to rise even further, in what may be described as a "vicious circle." The melting of glaciers in the arctic region will, along with the thermal expansion of ocean waters, increase the sea level, erode and flood coastal areas, and cause the extinction of many species.

Climate Change Considerations
Certain indicators of climate change in Michigan have already been observed. For example, in daily record temperature data, Michigan's new heat records outnumbered new cold records by 3 to 1 during the 1990s, and by 6 to 1 during the 2000s. Extreme heat problems are expected to increase in the future, and the MSP/EMHSD is coordinating with other agencies to assess the likely impacts of warming trends. It has long been known that although Michigan's winter season has been shortening, its winters will not disappear! Instead, a surprising pattern has recently been seen in which lessened differences in temperature between polar and temperate regions (due to the warming of the arctic and polar regions) can make it easier for a polar weather front to swing

southward across the United States. Although this jet stream movement occurs every winter as a normal part of Michigan's seasonal patterns, the 2013-2014 season showed an unexpectedly challenging aspect of the "polar vortex" phenomenon, in which a series of challenging weather events—ice storms, persistently cold temperatures, freezing rain, and heavy snowstorms—seemed to affect the state with increasing rapidity. Historical facts show that Michigan has experienced colder temperatures in the past (although specific records for individual days and locations will continue to be set over time), but one of the new patterns connected with climate change involves a lesser amount of time for persons to become acclimated to the cold weather—especially in the southern part of the Lower Peninsula. Increasingly mild fall months from October to early December may seem to suddenly give way to bitter cold, winds, ice, and snow, with the shorter winter season providing less time for people to adjust to the frigid weather. (By the calendar, winter is always three months long, but Michigan has long experienced winter weather conditions during months that are normally classified as part of Fall and Spring. One of the most prominent ways in which climate change has affected Michigan is in the shortening of its wintry weather, so that its seasons are becoming more closely aligned to those technically designated on the standard calendar as "winter.")

Significant Heat Waves Affecting Michigan

Following are brief synopses of some of the more significant heat waves that have affected Michigan in recent decades:

July 1936 – Michigan

During the second week of July 1936, a terrible heat wave struck Michigan, and particularly Detroit, with temperatures exceeding 100 degrees for up to seven days in a row (this varied by location—for example, Detroit had 7, West Branch and Alpena had 6, and Traverse City had 5). The temperature peaked at 112 degrees in Mio, setting a state record that still stands today. The extreme heat was an "equal opportunity" killer, causing many healthy adults to succumb to the heat at work or in the streets. Also, because most people relied on iceboxes to keep their food fresh, many heat-related deaths and illnesses occurred when the ice melted, causing the food to spoil. Statewide, 570 people died from heat-related causes, including 364 in Detroit. Nationally, the heat wave caused 5,000 deaths. Notice that these casualties disproportionately affected the large city of Detroit, and that Michigan was over-represented in terms of its population (11.4% of the national deaths were in Michigan).

August-September 1953 – Michigan

This summer included eleven days in a row with temperatures of 90 degrees or higher in Southeast Michigan, nine of which were 95 degrees or hotter, and also including two days that each hit 100 degrees.

July 1964 – Michigan

A heat wave lasted for twelve days, with temperatures all exceeding 90 degrees in Southeast Michigan. The highest such temperature was 95 degrees.

Summer 1988 – Central and Eastern U.S.

The 1988 drought/heat wave in the Central and Eastern U.S. also greatly impacted Michigan. Nationwide, the drought caused an estimated $40 billion in damages from agricultural losses, disruption of river transportation, water supply shortages, wildfires, and related economic impacts. The heat wave that accompanied the drought conditions was particularly long in Michigan – 39 days with 90 degree or better heat – eclipsing the previous record of 36 days recorded in the "dust bowl" days of 1934. During that 39-day stretch, the temperature in Southeast Michigan topped the 100 degree mark on 5 occasions, including a peak of 104 degrees on June 25. Nationwide, the 1988 drought/heat wave caused an estimated 5,000 to 10,000 deaths. (Again, the range of estimates is due largely to varying interpretations of "heat-related" death.)

July 1995 – Central and Eastern U.S.

During the period from July 11-27, 1995, the Central United States and many East Coast cities experienced a devastating heat wave. According to the National Oceanic and Atmospheric Administration, that heat wave caused 1,021 deaths - 465 of those occurring in the Chicago metropolitan area alone. Many of the deaths were low-income elderly persons living in residential units not equipped with air conditioning. Local utilities in Chicago were forced to impose controlled power outages because of excessive energy demands, and water suppliers reported very low levels of water in storage. In Milwaukee, Wisconsin, 85 heat-related deaths were reported during the July 11-27 period. Michigan experienced 28 heat-related fatalities in 1995, most of them occurring during the intense heat period in July. In addition to this tremendous human toll, the intense heat also caused the loss of tens of millions of cattle and poultry throughout the Midwest. This was the hottest summer on record for Southeast Michigan, in terms of having the highest average temperature in Detroit (74.5 degrees). The average August temperature was even higher, at 77.1 degrees, which also set a new record.

July 1999 – Midwest and East Coast

The July 1999 heat wave that struck the Midwest and East Coast resulted in an estimated 256 heat-related deaths in 20 states (including one in Kent County in Michigan). Most of the deaths occurred in urban areas in the Midwest, where temperatures soared above 90 degrees for much of the month and humidity levels were oppressively high. Numerous persons with heat-related problems (ranging from dehydration to heat stroke) were treated at hospitals in Detroit and other cities across the state throughout the heat wave.

June-August 2001 – Midwest and Central Plains

Extreme heat and humidity in the Midwest and Central Plains during parts of June, July and August sent heat stress index readings soaring well above 100 degrees Fahrenheit on many days. Communities across the region were forced to open "cooling centers" and take other steps in an attempt to avoid heat-related deaths among vulnerable segments of the population. Despite those efforts, heat-related deaths occurred in many areas – and unfortunately Michigan was no exception. In mid-June, three elderly residents of a Detroit-area nursing home died and five more were hospitalized due to heat-related stress. (Note: the deaths prompted a bill within the Michigan Legislature to require all nursing homes in Michigan to have air conditioning in resident rooms and common areas.) On August 1 and August 8, heat advisories were issued for many counties in the southern Lower Peninsula, with heat indices at 105 degrees for some

jurisdictions on the former date, and 110 degrees for some jurisdictions on the latter date. The National Climatic Data Center reports one death and 200 "injured" during early August, from excessive heat.

June 2003 – Michigan

Summer heat was part of the reason that Red Flag warnings were issued for two counties in the Upper Peninsula, warning of extreme wildfire risk. This was the same summer that saw a massive heat wave strike Europe and cause an estimated 21,000 deaths there. Paris, France recorded its highest temperatures since records had begun in 1873. Fortunately, Michigan did not experience those sorts of extreme problems.

Summer, 2006 – Southeastern Michigan

The National Climatic Data Center reports that 315 "injuries" occurred as a result of heat in Michigan—75 occurring on May 29, and 240 in late July and early August, although most of the latter were mild cases involving dehydration, some heat exhaustion, and only 6 known cases of heat stroke. A 5 day period of temperatures at or above 90 degrees started on July 29 for Southeastern Michigan. The heat index averaged between 105 and 110 degrees, and various temperature records were tied. A large number of cooling centers were provided for residents in need, and preparedness was very good, perhaps because the earlier May 29 event had provided a milder warning event that alerted communities to the potential for heat problems. In that earlier case, on Memorial Day, temperatures went as high as the mid-90s (with a temperature of 98 reported at Midland), and outdoor parade events caused many to swoon and be treated for dehydration and heat exhaustion.

August 2007 – Michigan

Red Flag warnings were issued for many Upper Peninsula counties, with extreme heat one of the main causes of the wildfire risk.

July 17, 2011 to July 22, 2011 – Southeast Michigan (Oakland and Wayne Counties)

A mid-July heat wave helped cap off the warmest month on record at Detroit. Three direct deaths were reported due to the heat wave, as heat indices were above 100 degrees. A 37-year-old Highland Township (Oakland County) man died from several factors including an enlarged heart, obesity and hyperthermia. A 60-year-old man died in Wayne County from hyperthermia, as he was found in his car with the windows rolled up. A 57-year-old man was also found dead due to hyperthermia in his Redford Township (Wayne County) group home.

June 28 to July 7, 2012 – Southeast Michigan (Wayne, Oakland, Macomb, Washtenaw, Genesee, Saginaw)

High temperatures climbed to around 100 degrees across much of southeast Michigan during the afternoon hours of June 28th, with heat indices climbing between 100 and 110 degrees. This led to an increase in heat-related hospitalizations. Temperatures slowly came down during the evening hours, with drier air slowly filtering in. Although Friday June 29th ended up being hot, with high temperatures in the low to mid 90s, the dry air helped to keep heat indices short of 100 degrees. This was followed almost immediate by an extended heat wave that gripped southeast Michigan during the first week of July, with temperatures topping out around 100 degrees on multiple days. Detroit set a record high on July 4th, reaching 102 degrees. Heat indices peaked around 110 degrees on July 4th and July 6th. Although no known heat deaths were reported, over 700 heat-related emergency room visits were reported statewide. Southeast Michigan tallies included 39 heat injuries in Wayne County, 28 in Oakland County, 20 in Macomb County, 13 in Genesee County, 10 in Saginaw County, and 5 in Washtenaw County.

July 14-19, 2013 – Southeast Michigan (Wayne, Oakland, Macomb, Washtenaw, Genesee, Saginaw)

A six-day heat wave impacted Southeast Michigan from July 14 through 19, with high temperatures ranging from the upper 80s to mid-90s. Heat Indices were mostly in the 90s, but Detroit Metro area hospitals reported an increase of 173 heat related illnesses during this stretch—80 in Wayne County, 50 in Oakland County, 25 in Macomb County, and 6 in each of Washtenaw, Genesee, and Saginaw Counties.

(**NOTE:** Oftentimes, heat waves exacerbate drought conditions, resulting in significant agricultural losses. For example, the summer heat of 1980 worsened the effects of a drought that caused over $20 billion in agricultural damage. The drought / heat wave of the summer of 1999 caused a nationwide total of more than $1 billion in damage—mainly to agricultural crops in the Eastern U.S. The "dust bowl" conditions of the 1930s are widely known and described in practically any U.S. history text. The most damaging drought / heat wave in the past few decades, however, was that of 1988, which affected the Central and Eastern United States. That event caused $40 billion in damage, in addition to contributing to many deaths. See the Drought section for more information.)

Significant Episodes of Extreme Cold Temperatures in Michigan

February 10 to 13, 1899 – Central and Western Lower Peninsula

Record low temperatures occurred multiple days in a row. At Baldwin (Lake County), four days in a row had record low temperatures: -36, -49, -48, and -37 degrees Fahrenheit. Grand Rapids also noted four days in a row that set all-time records: -21, -21, -23, and -24 degrees. At Big Rapids (Mecosta County), three days in a row set records: -33 degrees, -36 degrees, and -34 degrees. Similarly, Hastings and Muskegon also set records for three days in a row: the former with -26, -31, and -24, and the latter with -30, -29, and -22 degrees.

February 9, 1934 – Vanderbilt (Otsego County)

The coldest recorded temperature in Michigan was at this location in the northern Lower Peninsula—at 51 degrees below zero!

February 17, 1979 – Northern Michigan

This was one of the coldest days that ever occurred in Michigan, in terms of the widespread presence (across 14 monitoring locations) of top-ten coldest temperatures. At Trout Lake (Chippewa County), the low was -43 degrees. At Harrisville (Alcona County), it was -20 degrees. To the west, at Traverse City, the temperature went down to -37. At Standish (Arenac County), the low was -24 degrees, and at Houghton Lake, it was -34.

December 1993 to May 1994 – Upper Peninsula and Northern Lower Peninsula

This was the deep freeze disaster that was federally declared (#1028) and can be read about in the corresponding disaster report that appears in Attachment F of the 2011 Michigan Hazard Mitigation Plan. Ten counties (Gogebic, Ontonagon, Houghton, Marquette, Delta, Schoolcraft, Chippewa, Mackinac, Cheboygan, and Charlevoix) were declared disaster areas when record low temperatures caused the freezing and breakage of more than 3,200 water and sewer lines. Service to 18,700 homes was disrupted. Public costs were estimated at more than $12 million.

December 9, 1995 – Detroit

Winds averaged 20 to 25 mph and resulted in Wind Chill Temperatures of -30 to -35 degrees. Three deaths occurred from hypothermia in Detroit—two at street locations and one in a van. (The next morning, a man was also found frozen to death near his disabled vehicle 30 miles southeast of Ontonagon, where overnight low temperatures were -15 degrees and wind chill temperatures reached -60.)

February 3 to 5, 1996 – Stephenson (Menominee County)

There were three days in a row with record low temperatures in this area. The temperatures went down to -45, -44, and -41 at a spot 8 miles west-northwest of Stephenson, near the southern tip of the Upper Peninsula. On February 1, a few days before this event, a cold-related death was reported in Southeast Michigan, involving an elderly man who had wandered away from a nursing home in Detroit. That area of the state also experienced extreme cold, with Detroit's low on February 3 reaching -7 degrees. The temperature at Flint was zero degrees Fahrenheit, or below, for seven days in a row from January 31 to February 6.

January 17 to 19, 1997 – Southeast Michigan

The coldest weather of the winter occurred and resulted in two deaths from hypothermia—one in Bay City and the other (on January 12) in Warren. Low temperatures reached -6 at Detroit Metro Airport, and -9 at Flint's Bishop Airport.

January 1999 – Saginaw County

As a prelude, December 30, 1998 saw a damaging event at Saginaw Valley State University, when a sprinkler system pipe froze and burst, causing half a million dollars in damage at Brown Hall. Water was as deep as 3 to 4 inches in some offices by the time the break was discovered on New Year's Eve. Then, with January came more widespread events involving extreme cold. In Southeast Michigan, 3 persons died and 29 were confirmed as injured, as a cold blast crept around the sheltering Great Lakes and struck the southern Lower Peninsula. Temperatures went down to -13 at Ann Arbor and Tecumseh, and -10 in surrounding areas of Washtenaw, Lenawee, and Wayne Counties. The three deaths occurred in Oakland County on January 4. Confirmed injuries involved frostbite cases from a few hospitals in Oakland and Wayne Counties, and should be understood to represent only a small portion of the actual total from this event. On the early morning of January 11, a daily low temperature of -4 degrees was recorded, and on that day more than 120 water main breaks took place in the City of Detroit. A very large water main also ruptured in downtown Adrian, causing a shortage for 22,000 residents. Property damage was estimated at $1.3 million.

December 21 to 29, 2000 – Southeast Michigan (including the thumb area)

In late December 2000 after heavy snow had ended, extreme cold temperatures invaded southeast Michigan, including portions of the thumb region. Temperatures never got out of single digits on the 22nd, with Detroit seeing a high of only 4 degrees, after a morning low of -3. Flint wasn't much better, recovering from a low of -5 to reach 8 degrees in the afternoon. Christmas morning had a morning low of -13 degrees at Flint, setting an all-time record for the month of December. Three nights later, Flint would give the new record a run for its money, coming up just short with a low of -11 on the 28th. The arctic weather would take a toll on pipes. Both Ypsilanti High School and Chelsea High School had pipes burst over Christmas weekend, damaging classrooms. Several buildings on the University of Michigan campus in Ann Arbor had similar ruptures, including the School of Dentistry and Wolverine Tower. The cold also hampered shipping interests. Ice formation was extremely rapid on the Great Lakes and the connecting waterways. Several freighters got stuck in ice on both the Detroit River and Lake St Clair, blocking the shipping channel and bringing dozens of ships to a halt. Icebreaker assistance was needed to free the freighters. Ferry service on the St Clair River between Michigan and Canada was also interrupted due to ice jams. The end result was the 4th coldest December of all time in Detroit, and the 2nd coldest at both Flint and Saginaw. No other December on record comes close to this combination of heavy snow and brutal cold.

January 2003 – Lower Peninsula

Temperatures averaged well below normal across the Great Lakes region for much of January. For a three week period, the temperature never rose above freezing. Temperatures fell below zero for several nights during this period. Frozen pipes and water main breaks occurred in many areas of Detroit and its suburbs. The cities of Flint and Saginaw also had several reports of water main breaks. Several area schools had to cancel classes due to frozen pipes. Many homeless shelters were filled to capacity and area hospitals reported dozens of cases of frostbite. Three deaths were also attributed to this cold spell.

February 3 to 6, 2007 – Southeast Michigan

The worst cold wave event since the 1990s struck the region on February 3 and did not let up until February 6. Temperatures went as low as -7 at Saginaw and -5 at Flint, and winds of 15 to 25 mph included gusts of up to 35 mph. Wind Chill Temperatures ranged from -15 to -25 throughout almost the entire event, causing nearly every school district to cancel classes for one to two days. Hospitals reported numerous cold-related illnesses and frostbite cases. Area homeless shelters were filled to capacity. One death was attributed to the bad weather. Frozen pipes and water main breaks occurred throughout the area, and flooding occurred in cases where these involved sprinkler system pipes. Total damages were estimated at $425,000. According to AAA, there were more than 20,000 vehicle service calls from Michigan due to the cold weather—more than had been seen for nearly 10 years.

February 9-11, 2008 – Upper Peninsula

Temperatures of 5 to 15 below zero combined with around 35 mph wind gusts drove bitterly cold wind chill values down to 25 to 40 below zero over much of Upper Michigan from the night of the 9th into the morning of the 11th. The powerful Arctic cold front pushed through the Upper Great Lakes on the afternoon and evening of the 9th and also produced blizzard conditions with lake effect snow and blowing snow over portions of Upper Michigan into the 10th. Many schools were either canceled or delayed on the 11th. AAA Michigan reportedly responded to numerous motorists' calls of dead batteries or fuel line freezes during the extreme cold.

January 14-18, 2009 – Southeastern Michigan

An arctic air mass become firmly established over the Great Lakes region on January 14th and persisted through the 18th, producing the winter season's coldest temperatures. Temperatures fell below zero all four days, with wind chill values in the 5 to 30 below range during the majority of the time. Detroit's low temperatures for January 14-18th were as follows: -3, -3, -15, -11. Wind chill values also plummeted to 20 to 40 below zero from late evening on the 13th through the morning of the 16th throughout much of the Upper Peninsula.

April 27, 2012 – Lower Michigan – Late Freeze

A killing freeze caused extreme damage to agriculture in the Lower Peninsula, particularly in the fruit belt of its northwest. Traverse City saw low temperatures of 25 degrees on April 27th, 31 degrees on the 28th, and 26 degrees on the 29th. Although these values were not greatly colder than normal lows, because of a stretch of unprecedented warmth in mid-March which had included five consecutive 80-degree days (17th-21st) that had caused fruit trees to bud out far ahead of schedule, these trees were left vulnerable when more normal April temperatures returned. The tart cherry crop was a total loss, while other orchard fruits such as sweet cherries, apples, pears, and peaches saw losses in excess of 90% of the expected crop. Total losses exceeded $100M.

Early 2014 – Statewide

Several times during the 2013-2014 winter season, very low temperatures were felt across the state, for periods of time that placed many persons at risk. This sometimes coincided with ice storms, power failures, propane shortages, and transportation blockages which caused the effects of the extreme cold

temperatures to be more pronounced. The media made the term "polar vortex" popular during these extreme temperature events. More information about these events will be available in a future edition of this document, since they are still ongoing at the time of writing.

Programs and Initiatives

Extreme Summer Heat

Excessive Heat Events Guide Book – A product of the Environmental Protection Agency, in conjunction with FEMA, NOAA, and the Center for Disease Control and Prevention, this booklet can be obtained online at http://www.epa.gov/heatisland/about/heatguidebook.html. It provides an overview of heat impacts, sources of risk, notification and response programs, and recommendations.

Summer Heat Contingency Planning – In the aftermath of the extreme summer heat events of 1980 and the early 1990s, many major cities began to develop contingency plans for addressing heat-related hazards. The major elements of these plans include: 1) enhanced weather monitoring to better predict periods of extreme heat; 2) increased outreach to the elderly and other vulnerable individuals; 3) establishment of "cooling centers" for those most affected by the heat; and 4) enhanced public information campaigns to inform people of the perils of extreme summer heat and the resources available to them. In Michigan, cities such as Detroit and Lansing, among others, now address extreme summer heat contingencies in their emergency planning efforts.

Low Income Home Energy Assistance Program / State Emergency Relief Program – The LIHEAP is a federally-funded program to help eligible low income households meet their home heating or cooling needs. The money is used to help pay high utility bills or buy fans or air conditioners for persons considered at risk from extreme summer heat and it helps to pay for heat and weatherization during extreme winter cold. In 2003, about 4.6 million Americans received over $1.5 billion in assistance under the LIHEAP. Michigan received $40.8 million of that money to help aid low income citizens with heating expenses. In Michigan, the state Department of Human Services determines which families are eligible. In addition, the State Emergency Relief (SER) Program can also be used to alleviate the dangers of extreme heat and cold for Michigan families by providing financial assistance for home heating, electric and water bills.

Extreme Winter Cold

Since illness and death from hypothermia are not only seen in association with prolonged periods of cold temperatures, efforts to prevent hypothermia must be ongoing throughout periods of cooler weather. Because elderly persons are particularly vulnerable to hypothermia, prevention efforts must be primarily directed to them. Family, friends, neighbors, and local governmental and voluntary agencies can help ensure that all dwellings in which elderly persons reside are properly heated. This may require that a regular outreach program be established for this purpose. Local communities should also have adequate housing codes that require dwellings to have furnaces capable of maintaining sufficient room temperature for the winter conditions that will normally be expected. Governmental authorities, voluntary agencies and utilities can also assist those elderly persons that cannot pay all or part of their heating bills by providing financial assistance and/or making special arrangements for payment. Finally, governmental and voluntary agencies should, in conjunction with local media, continue to address the dangers associated with cold temperatures through regular public information and awareness campaigns. The combination of all these activities certainly will not prevent all cold temperature-related injuries and deaths, but it will go a long way toward preventing a large share.

Hazard Mitigation Alternatives for the Extreme Temperatures Hazard

- Organizing outreach to vulnerable populations during periods of extreme temperatures, including establishing and building awareness of accessible heating and/or cooling centers in the community, and other public information campaigns about this hazard.
- Increased coverage and use of NOAA Weather Radio.

Tie-in with Local Hazard Mitigation Planning

Because many means of implementing mitigation actions occur through local activities, this updated MHMP places additional emphasis on the coordination of State-level planning and initiatives with those taking place at the local level. This takes two forms:

1. The provision of guidance, encouragement, and incentives to local governments by the State, to promote local plan development, and
2. The consideration of information contained in local hazard mitigation plans when developing State plans and mitigation priorities.

Regarding the first type of State-local planning coordination, MSP guidance has included the "Local Hazard Mitigation Planning Workbook" (EMD-PUB 207), which is currently being updated for release by 2015. For the second type of State-local planning coordination, a section later in this plan summarizes hazard priority information as it has been reported in local hazard mitigation plans. Here, it will merely be noted that extreme temperatures were identified as one of the most significant hazards in local hazard mitigation plans for the following counties: Alger, Barry, Berrien, Cass, Gogebic, Leelanau, Mason, Menominee, Monroe, Montmorency, Muskegon, Oceana, Otsego, Wayne (14 counties).

FOG

Fog: Condensed water vapor in cloudlike masses lying close to the ground and limiting visibility.

Hazard Description

Fog forms near the ground when water vapor condenses into tiny liquid water droplets that remain suspended in the air. Many different processes can lead to the formation of fog, but the main factor is saturated air. Two ways that air can become saturated are by cooling it to its dew point temperature or by evaporating moisture into it to increase its water vapor content. Although most fog, by itself, is not a hazard because it does not actually apply destructive forces, the interaction between humans and fog can be a dangerous situation, sometimes resulting in disastrous consequences. It must be noted, however, that **freezing fog** (a hazard for which the National Weather Service does issue special statements) can cause direct harm by causing slickness on roadways and thus leading to serious transportation accidents (examples are provided later in this chapter).

Haze and Smog

Haze occurs when dust, smoke and other pollutant particles obscure the normal clarity of the sky. It occurs when dust and smoke particles accumulate in relatively dry air. When weather conditions block the dispersal of smoke and other pollutants, they concentrate and form a usually low-hanging shroud that impairs visibility and may become a respiratory health threat, as well as make safe driving more difficult. Dense haze caused by industrial pollution is also known as smog. This hazard may cause public health problems, so it is mentioned in this subsection but is not given particular emphasis since this plan has more of an emergency management focus. It is noted here as an area of potential overlap and future coordination with other agencies. The Michigan Department of Community Health and the Michigan Department of Natural Resources may do more with this issue in the future, if the effects become severe enough. Since it may be possible that climate change issues cause this to be a more frequent and ongoing concern in Michigan, it is mentioned here. In general, however, air quality has generally improved since the effects of the Clean Air Act, other legislation, regulatory measures, and shifts away from heavy industry in Michigan's economy.

Smoke-producing hazards may have an effect that seems visually comparable to fog. For example, wildfires, hazardous materials incidents, structural fires, major transportation accidents, or industrial accidents may produce clouds of smoke that can obscure visibility and increase the risk of transportation accidents.

Hazard Analysis

In considering severe and high-impact meteorological events, attention can easily become focused on the more dramatic storms. Tornadoes and hurricanes for example, are readily recognized by the general public and the meteorological community alike for their devastating consequences. Fog, on the other hand, does not lend itself as readily to this categorization. Yet, both in cost and casualties, fog has consistently impacted society, and in particular the transportation sector - sometimes with deadly consequences. Fog has played a contributing role in several multi-vehicle accidents over the past several years. While statistics suggest that highway accidents and fatalities, in general, have fallen, that trend is not evident with respect to accidents and fatalities caused by fog.

Fog can be very dangerous because it reduces visibility. Although some forms of transport can penetrate fog using radar, road vehicles have to travel slowly and use more lights. Localized fog is especially dangerous, as drivers can be caught by surprise. Fog is particularly hazardous at airports, where some attempts have been made to develop methods (such as using heating or spraying salt particles) to aid fog dispersal. These methods have seen some success at temperatures below freezing.

One major fog event is estimated to occur in Michigan approximately every two years. Property damage can be significant for vehicles, although real property and structures are usually unaffected. Fog has not yet been identified as one of the most significant hazards in any of Michigan's local hazard mitigation plans.

Fog History for Michigan Counties – arranged by region – Jan. 1996 to Oct. 2013
(The Lower Peninsula regions are ordered by "tiers" from south to north, west to east)
Please refer to the Michigan Profile Map section for an explanation of regional divisions

COUNTY or area	**Fog Events**	**Days with Fog**	**Injuries**	**Deaths**
Washtenaw	2	2		
Wayne	2	2		
.Livingston	1	1		
Oakland	1	1		
Macomb	1	1		
5 Co Metro region	**1.4 avg.**	**1.4 avg.**		
Berrien				
Cass				
St. Joseph				
Branch				
Hillsdale				
Lenawee				
Monroe	1	1		
.Van Buren	1	1		
Kalamazoo	1	1		
Calhoun	1	1		
Jackson	1	1		
.Allegan	1	1		
Barry	1	1		
Eaton	1	1		
Ingham	1	1		
.Ottawa	1	1		
Kent	1	1		
Ionia	1	1		
Clinton	1	1		
Shiawassee	1	1		
Genesee				
Lapeer	2	2	1	1
St. Clair	1	1		
.Muskegon				
Montcalm				
Gratiot				
Saginaw	1	1		
Tuscola				
Sanilac	1	1		
.Mecosta				
Isabella				
Midland	1	1		
Bay	1	1		
Huron				
34 Co S Lower Pen	**0.6 avg.**	**0.6 avg.**	**1**	**1**

Continued on next page…

Part 2 of Michigan County Fog Hazard History table

.Oceana				
Newaygo				
.Mason				
Lake				
Osceola				
Clare				
Gladwin				
Arenac				
.Manistee	1	1		
Wexford				
Missaukee				
Roscommon				
Ogemaw				
Iosco				
.Benzie				
Grand Traverse				
Kalkaska				
Crawford				
Oscoda				
Alcona				
.Leelanau				
Antrim				
Otsego				
Montmorency				
Alpena				
.Charlevoix				
Emmet				
Cheboygan				
Presque Isle				
29 Co N Lower Pn	**0.03 avg.**	**0.03 avg.**		
Gogebic	3	3		
Iron	2	2		
Ontonagon	3	3		
Houghton				
Keweenaw	3	3		
Baraga	4	4		
.Marquette	4	4		
Dickinson	3	3		
Menominee	3	3		
Delta	4	4		
Schoolcraft	4	4		
Alger	4	4		
.Luce	4	4		
Mackinac				
Chippewa				
15 Co Upp.Pen	**2.7 avg.**	**2.7 avg.**		
MICHIGAN TOTAL	**82**	**19**	**1**	**1**

Impact on the Public

The primary risks from fog involve the dangers of traveling under conditions of limited visibility. Although some modes of transportation, such as aircraft, are well-regulated, other modes, including simple pedestrian travel, may involve risks that have not been properly accounted for by those who are focused merely on reaching their destination as quickly as possible. The most substantial impacts have recently involved drivers whose bad habits (primarily that of not maintaining safe speeds and following distances) proved to be simply unsustainable under conditions of reduced visibility, resulting in severe crashes and subsequent roadway obstruction. In some circumstances, these conditions of reduced visibility can arise very quickly, although careless drivers, in their desire for fast travel conditions, may erroneously try to ignore the risks from reduced visibilities, in the hope that the condition will suddenly correct itself before any harm is caused.

Impact on Public Confidence in State Governance

This hazard is not expected to cause serious impacts upon public perception of the State's governance, so long as the cautionary messages issued by the National Weather Service and other agencies are received and understood. One reason for the estimated lack of impact on public confidence is that (1) the hazard is typically a localized one not presumed to be dealt with at a State level, (2) public announcements tend to be made when visibility gets too low, and (3) the airline industry operates under regulations (and also uses special equipment) to alleviate the risks from fog. The most serious incidents in Michigan, in which extensive chain-reaction car crashes have occurred on interstate highways, could arguably be connected with too lax of enforcement of fundamental traffic laws (primarily the infractions of following too closely and speeding), but a large proportion of the public, which persists in such unsafe and often unconscious driving habits, seems unlikely to perceive or understand any such hypothetical connection between these conditions.

Impact on Responders

In certain circumstances that require an emergency response, heavy fog may cause impediments and risks that would not normally be present. This is especially true in cases involving high-speed mechanized transportation that requires good visibility to maintain adequate and safe control and maneuvering ability, and for situations that involve search and rescue operations, for which visibility may be very important in locating and assisting victims. Response activities involving aircraft, for example, may be impaired or harmfully delayed by fog.

Impact on the Environment

Fog on its own does not directly impact the environment. However, fog may reduce visibility and can create dangerous traveling conditions. Transportation accidents involving a chemical release may cause great harm to the environment by releasing toxins into the soil, groundwater or air. (Please refer to the chapter on hazardous materials, in the Technological-Industrial Hazards section of this plan.)

Recent Significant Fog-Related Incidents in Michigan

January 11 to 13, 1995 – Michigan's Lower Peninsula

In January 1995, dense fog blanketed much of Lower Michigan from the evening of the 11th through the morning on the 13th. The fog caused numerous traffic accidents, which resulted in four fatalities. School openings were delayed in parts of southwest Michigan as visibilities dropped to near zero. Low visibilities caused most of the flights at Detroit's metro airport to be cancelled, delayed or diverted on the 12th. About seventy-five flights were also delayed or cancelled at Kent County International Airport in Grand Rapids.

October 25- 26, 2000 – Southeastern Metro Areas

On the morning of October 25, dense fog dropped visibilities to only about an eighth of a mile at the MBS International Airport (Saginaw County), causing most of the morning flights to be cancelled. In addition, several area school districts delayed the start of classes that morning. On the following morning, October 26, dense fog had a similar effect upon Metropolitan Detroit, causing dozens of flights to be delayed at the Detroit Metro Airport, and slowing the traffic of morning commuters on the area's roads and highways.

October 11 to 12, 2002 – Lapeer County

At certain times, dense fog reduced visibility to near zero in many locations. A 17 year old teenager was killed in Goodland Township when his pickup truck collided with a dump truck that was hauling a trailer. In a separate incident, a slightly older 19 year old driver failed to stop at a sign, and struck a school bus, resulting in one injury.

January 12, 2005 – Ingham County

Up to 200 cars collided on an expressway, in a chain of crashes blamed on heavy fog in Ingham County on January 12, 2005. Two people were killed and thirty-seven others were taken to local hospitals. It was the worst crash in mid-Michigan in recent years and shut down both lanes of Interstate 96 between Okemos and Webberville for several hours. The dense fog cut visibility to around ten feet during rush hour.

September 13, 2006 – Shiawassee County

Dense fog was reported to have caused three semi-trucks to roll over, a car crash and a separate car fire on I-69. As a result, that expressway had to be shut down in both directions between M-71 and the Grand River exit (a distance of about 4.5 miles), until the accidents could be cleared. A total of seven persons were injured in these crashes.

November 24, 2006 – Monroe County

In November, 2006 freezing fog caused zero visibility and created extremely dangerous driving conditions that led to numerous vehicle collisions. A semi-truck rollover accident resulted in the death of one man. Portions of I-275 were shut down for several hours due to the accident. Ten injuries were (indirectly) associated with the hazardous fog on this day.

January 12, 2009 – Southern Lower Peninsula

The National Weather Service issued an advisory (for 17 counties) about freezing fog that would not only reduce visibility, as normal fog does, but would also freeze upon some roadways and "aggravate already slick conditions."

May 22, 2010 – Manistee County

Dense fog inhibited visibility in the area. At the entrance to Manistee Harbor, a fishing boat struck a pier, took on water, and submerged. Seven persons were rescued from the water, but there were two injuries and a death that still resulted (plus four persons who were less seriously harmed and merely required medical treatment on-site).

Programs and Initiatives

National Weather Service Detection Systems

The National Weather Service has completed a major modernization program designed to improve the quality and reliability of weather forecasting. The keystone of this improvement is Doppler Weather Surveillance Radar, which can more easily detect severe weather events that threaten life and property. Although the NWS Doppler Radar does not directly detect fog, the point of greatest importance is that the lead-time and specificity of warnings for severe weather have improved significantly, and a dense fog advisory is reported when widespread or localized fog reduces visibility to a quarter mile or less.

Weather satellites are useful tools in monitoring and detecting the formation of low stratus clouds and fog. Satellite images are obtained using two Geostational Operational Environmental Satellites (GOES) and NOAA polar satellites. Remote sensing with GOES and NOAA polar satellites allows for the continuous monitoring of weather across the Earth. Channels on these satellites allow the use of infrared images at night. During the daytime hours, visible satellite data can be used to locate areas of stratus clouds and fog, and water vapor imagery has also been found to be helpful.

Automated Surface Observation System (ASOS)

In the 1980s the National Weather Service (NWS), the Federal Aviation Administration (FAA), and the Department of Defense (DOD) were faced with the need to find cost-effective ways to provide pilots with critical weather information. With NWS in the lead role, these federal agencies began development of automated sensors that were intended to eventually replace human weather observers. This automated sensor development culminated in the fielding of two systems: The Automated Weather Observation System (AWOS) and the Automated Surface Observation System (ASOS). AWOS and ASOS sensors provide continuous measurements of ceiling, visibility, temperature, dew point, wind speed and direction, and precipitation. All ASOS sites and some AWOS sites also have lightning detection and reporting, courtesy of the Automated Lightning Detection and Reporting System (ALDARS). Beginning in 1992, ASOS sites started to replace manual surface aviation observations. There are currently 882 federally sponsored ASOS sites around the country, and 24 of them are in Michigan. Fog is considered to be an obstruction to visibility when the temperature and dew points are within 5°F of each other. When the difference is more than five degrees, haze is reported.

Automated Weather Observing System (AWOS)

The Automated Weather Observing System (AWOS) is a suite of sensors, which measure, collect and disseminate weather data to help meteorologists, pilots and flight dispatchers prepare and monitor weather forecasts, plan flight routes, and provide necessary information for correct takeoffs and landings. An AWOS provides minute-to-minute updates that are usually provided to pilots by a VHF radio on a frequency between 118 and 136 MHz. An AWOS is categorized as either federal or non-federal. A federal AWOS was purchased and is currently maintained by the FAA. A non-federal AWOS is purchased and maintained by state, local, and private organizations. The sensors measure weather parameters such as wind speed and direction, temperature and dew point, visibility, cloud heights and types, precipitation, and barometric pressure. The AWOS does not predict weather, but may send current information to weather offices where forecasts are produced using this information

along with computer model outputs, satellite photos and radar images. There are currently twenty-eight Automated Weather Observing Systems in Michigan.

Information Broadcast by an AWOS III

Airport Identifier	Zulu Time
Sky Conditions	Visibility
Wind Speed	Wind Direction
Temperature	Dew Point
Altimeter Setting	Remarks
Density Altitude	Wind Gusts

Advanced Weather Interactive Processing System (AWIPS)

The Advanced Interactive Processing System (AWIPS) is an interactive computer software system with a full suite of satellite imagery used to analyze meteorological and hydrological data. This system is used by the National Weather Service (NWS) to predict weather patterns, prepare forecasts, and issue weather-related warnings. AWIPS has been the foundation of the NWS operations for the past decade but was planned for update to AWIPS II in 2011. The newly updated software, which is being developed by the NWS and a private entity, will allow data to be processed more efficiently, resulting in greater accuracy of weather forecasting.

Lighthouses

Lighthouses are key parts of the infrastructure for water transportation, especially when dealing with the dangerous element of fog. Michigan has more lighthouses than any other U.S. state, by quite a large margin. In addition to traditional lighthouses, Michigan has many minor aids to navigation, in the form of cylindrical steel towers with navigation beacons at the top. These are known as D9 towers (named after the ninth Coast Guard district). Some of the D9 towers are regarded locally as being lighthouses, but most are not. Below is a list of lighthouses in Michigan that are still operational.

Operational Lighthouses in Michigan

Name	Lake	Name	Lake
Detroit River Light	Erie	Minneapolis Shoal Light	Michigan
Cheboygan River Range Front Light	Huron	Muskegon South Breakwater Lights	Michigan
Detour Reef Light	Huron	North Manitou Shoal Light	Michigan
Fort Gratiot Light	Huron	Escanaba Light	Michigan
Forty Mile Point Light	Huron	Fourteen Foot Shoal Light	Michigan
Harbor Beach Light	Huron	Point Betsie Light	Michigan
Martin Reef Light	Huron	Poverty Island Light	Michigan
Middle Island Light	Huron	Frankfort North Breakwater Light	Michigan
Poe Reef Light	Huron	Grand Haven South Pier Head Lights	Michigan
Pointe Aux Barques Light	Huron	Grays Reef Light	Michigan
Port Austin Reef Light	Huron	Seul Choix Pointe Light	Michigan
Port Sanilac Light	Huron	Skillagalee Light	Michigan
Presque Isle Lights	Huron	South Haven South Pierhead Light	Michigan
Round Island Passage Light	Huron	St. Helena Island Light	Michigan
Sturgeon Pointe Light	Huron	St. James Light	Michigan
Tawas Pointe Light	Huron	White Shoal Light	Michigan
Thunder Bay Island Light	Huron	Lake St. Clair Light	St. Clair
Alpean Light	Huron	St. Clair Flats South Channel Range	St. Clair
Spectacle Reef Light	Huron	Au Sable Light	Superior
Round Island Light	Mackinac Straits	Big Bay Point Light	Superior
Little Rapids Cut Range Light	St. Mary's River	Passage Island Light	Superior
Big Sauble Point Light	Michigan	Rock of Ages Light	Superior
Charlevoix Light	Michigan	Gull Rock Light	Superior
Charlevoix South Pier Light	Michigan	Huron Island Light	Superior
Holland Harbor (South Pier Head Light)	Michigan	Isle Royale Light	Superior
Lansing Shoal Light	Michigan	Keweenaw Waterway Entrance Light	Superior
Little Point Sable Light	Michigan	Manitou Island Light	Superior
Ludington North Breakwater Light	Michigan	Marquette Harbor Light	Superior
Manistee Light	Michigan	Mendota Light	Superior
Manistique (East Breakwater) Light	Michigan	Munising Range Lights	Superior
Menominee Light	Michigan	Eagle Harbor Light	Superior
		Whitefish Pointe Light	Superior

Michigan Lighthouse Assistance Program Grants

The Michigan Lighthouse Assistance Program was established by the Michigan legislature in 1999 to assist local groups in preserving and protecting lighthouses. The program arose from the efforts of the Michigan Lighthouse Project, out of concern for the disposal of some 70 lighthouses by the U.S. Coast Guard. Two-thirds of Michigan's lighthouses currently under federal ownership are scheduled for disposal within the next decade.

Hazard Mitigation Alternatives for the Fog Hazard

- Increased coverage and use of NOAA Weather Radio.
- De-icing measures (for freezing fog), as would be used for other ice-related hazards.

Tie-In With Local Hazard Mitigation Planning

Because many means of implementing mitigation actions occur through local activities, this updated MHMP places additional emphasis on the coordination of State-level planning and initiatives with those taking place at the local level. This takes two forms:

1. The provision of guidance, encouragement, and incentives to local governments by the State, to promote local plan development, and
2. The consideration of information contained in local hazard mitigation plans when developing State plans and mitigation priorities.

Regarding the first type of State-local planning coordination, MSP guidance has included the "Local Hazard Mitigation Planning Workbook" (EMD-PUB 207), which is currently being updated for release by 2015. For the second type of State-local planning coordination, a section later in this plan summarizes hazard priority information as it has been reported in local hazard mitigation plans. Here, it will merely be noted that none of the local hazard mitigation plans have yet stated that the fog hazard is one of the most significant in that jurisdiction.

I. Natural Hazards
B. Hydrological Hazards

The following outline summarizes the significant hydrological hazards covered in this section:

1. Flooding
    - a. Riverine flooding
    - b. Great Lakes Shoreline Hazards
    - c. Dam failures
2. Drought

Most of the apparent impacts upon Michigan residents come from flooding. The section entitled Riverine flooding focuses upon inland areas and mapped floodplains, but consideration also needs to be given (where information allows) to urban flood hazards. Not all flooding occurs within recognized floodplain areas, or adjacent to rivers and lakes. In some cases, melting snow or other runoff waters pool in low-lying areas, damaging structures and inhibiting the function of roads and infrastructure. In other cases, some type of breakdown in an area's pumping or drainage infrastructure may result in a damaging flood. This type of flooding typically occurs in well-developed urban or suburban areas, and therefore is often called urban flooding. It tends to occur due to either (1) a breakdown in infrastructure or (2) inadequate planning and design standards on the part of builders, developers, engineers, architects, and planners.

One of Michigan's most heavily damaging federally-declared disasters (#1346) was the result of urban flooding, in September of 2000. A tremendous amount of damage had been caused by the entrance of water into basements throughout the densely developed central areas of the Metropolitan Detroit area. A historical problem with the development of many urban areas has involved the use of infrastructure whose original design was appropriate for the expected functions of the central city, but that has become overburdened with the effects of considerable "suburban" developments upstream, which send extra runoff into the system. In other cases, inadequate or deteriorating components exist at the connections between the drainage/sewage system and the structures they serve. Leaks, inadequate backflow preventers, drain openings clogged with leaves or other debris, the inadequacies of combined storm/sanitary sewer systems, and other problems can all cause water and sewer systems to experience problems under certain circumstances.

Fortunately, many important flood mitigation activities have taken place in recent decades, including the separation of combined sewer systems, the installation of backflow preventers in houses, and the dredging, expansion, and re-design of drainage systems. Numerous activities have demonstrated that municipalities and their utility providers have been able to learn from the hard lessons of the past. Nevertheless, a consideration of the types of flood events that have occurred in the past will help to keep such events from recurring in the future. Whether the urban flooding of September 2000, the basement flooding near Lake St. Clair in the early 1970s, or the channel changes and ice jams that caused flood problems to emerge in various other areas (such as Robinson Township, Ottawa County) over the past few decades, Michigan and its communities have learned lessons and taken many steps to mitigate flood impacts in the future. More importance is now placed on the preventive role of planners in coordinating their land development plans with the existing knowledge of local floodplains, wetlands, sewer capacity, and upstream development and hydrology. There has been an increased use of stormwater detention and retention areas, and a great deal of progress in the separation of combined sewer systems. However, drainage systems will always need to be maintained—to dredge out the sediment that would otherwise reduce stream capacities, to upgrade components of the infrastructure that have become worn or had their capacity exceeded, to identify and upgrade bridges that act as barriers to water flows, to remove dams that no longer provide a net benefit to nearby lands, to clear away clogging debris such as leaves and branches and logs, and to efficiently clear away ice jams that would similarly block and divert draining waters away from their intended, safe course.

Progress has also been made in collecting information that will help to identify and prioritize areas that are in need of flood mitigation activities. A system of stream gauges exists across Michigan and is linked with a real-time remote monitoring system through the internet (www.waterwatch.usgs.gov), allowing the assessment of risks and responses to both local flooding and regional drought conditions. A program of updated floodplain maps has also been proceeding (http://www.fema.gov/plan/prevent/fhm/mm_main.shtm), to not only update the boundaries of these maps, but also to

enable these maps to be readily used in digital information processing. A developing database of natural hazard events has been online for several years now (http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwEvent~Storms). Detailed aerial photos are now available at various sites on the internet, theoretically allowing a comparison between the identified at-risk areas and the actual structures and infrastructure that exist there. However, it will take years, plus adequate funding and staffing, for all of this new information to start to be adequately processed and incorporated into state and local plans.

Overlap Between Hydrological Hazards and Other Sections of the Hazard Analysis

Hydrological hazards stem from precipitation patterns, which are affected by the types of events described in the **Weather Hazards** sections on thunderstorms, severe winter weather, and extreme temperatures. Thunderstorms, snowstorms, and ice/sleet storms produce precipitation that can cause or exacerbate flooding—either immediately or when the frozen precipitation melts. In addition, ice can build up and block critical parts of drainage-ways and thus cause flooding. In the case of extreme temperatures, freeze events have caused flooding when pipes and water mains have broken, while heat waves may worsen the impacts of a drought. Severe winds and tornadoes tend to produce woody debris from the damage they do to trees, utility poles, etc., and this debris can, like ice, build up and jam streams or drains and thus cause flooding to occur. The same sort of debris might also arise from the **Ecological Hazards** of wildfires and invasive species (which can weaken and kill trees and thus cause them to fall).

Technological Hazards that inhibit the smooth functioning of drainage or water supply infrastructure may cause or exacerbate either the flooding or drought hazards. For example, sewer pumping and lift stations can go out of operation during a power failure (unless supplied with power by a back-up system or generators), and cause flooding to occur, or a reduction in water supply—especially in heavily developed urban areas. Transportation accidents also have the potential to cause power failures or even water main breaks, and thus produce flooding or exacerbate drought impacts.

Human-Related Hazards such as terrorism, sabotage, or civil disturbances, may cause water-related infrastructure to be disabled and thus cause or worsen flood or drought events. Public health emergencies may involve the contamination of already-limited water supplies during a drought and thus compound the human impacts of that hazard.

Examining the issue from a different direction, in terms of the effects that can be produced <u>by</u> flood or drought hazards, it can be seen that both flood and drought may, in their own different ways, reduce the quality of an area's water supply—possibly to the point of creating the risk of a public health emergency. Civil disturbances might result from a drought that involves a very limited supply of water for human consumption, or from some form of mismanagement, negligence, or culpability (real or imagined) on the part of some specific agency or actor. An example might be a damaging flood caused by a city's public works department, which might result in hostile protests and the destruction or sabotage of property.

It is also known that floods can cause hazardous materials incidents and transportation accidents, when facilities and transportation infrastructure is in the flooded area. Flood waters in urban or polluted areas tend to be contaminated with chemicals, debris from roadways and cars, and industrial residues. Flood waters can also carry the bodies of animals and humans, and exacerbate insect, snake, rodent, mold, and mildew problems that affect the public health of the area. Floods may hinder the response to emergency events (such as fires, accidents, or utility failures). Floodwaters may cause infrastructure failures, either due to physical impacts and erosion of roads and facilities, or by interfering with the functioning of equipment, electrical supply, etc. in the flooded area. Droughts increase the likelihood of wildfire events, and may also cause land subsidence.

Flood Hazards

Flood hazards in Michigan include dam failures, riverine flooding, and Great Lakes shoreline flooding and erosion. Flooding in Michigan can cause extensive property damage, reduced quality of life, and even injuries and deaths. The National Flood Insurance Program offers one form of security to communities that have flood-prone areas. As of December 2010, Michigan had 25,555 flood insurance policies in place. More information about this topic is provided in the Riverine Flooding section. Every year, flooding causes more than $2 billion of property damage in the U.S. In a high risk area, a home has at least a 26% chance of being damaged by a flood during the course of a 30-year mortgage, compared to a 9% chance of being damaged by fire. The map below shows the major rivers in Michigan and their watersheds (the area in which water runs off into the river and is then carried to one of the Great Lakes).

Riverine Flooding

The overflowing of rivers, streams, drains and lakes due to excessive rainfall, rapid snowmelt or ice.

Hazard Description

Flooding of land adjoining the normal course of a stream or river has been a natural occurrence since the beginning of recorded history. If these floodplain areas were left in their natural state, floods would not cause significant damage. Development has increased the potential for serious flooding because rainfall that used to soak into the ground or take several days to reach a river or stream via a natural drainage basin now quickly runs off streets, parking lots, and rooftops, and through man-made channels and pipes. Some developments have also encroached into flood plain areas and thus impeded the carrying capacity of the drainage area.

Hazard Analysis

Floods can damage or destroy public and private property, disable utilities, make roads and bridges impassable, destroy crops and agricultural lands, cause disruption to emergency services, and result in fatalities. People may be stranded in their homes for several days without power or heat, or they may be unable to reach their homes at all. Long-term collateral dangers include the outbreak of disease, widespread animal death, broken sewer lines causing water supply pollution, downed power lines, broken gas lines, fires, and the release of hazardous materials.

Floodprone areas are found throughout the state, as every lake, river, stream and open drain has a floodplain. The type of development that exists within the floodplain will determine whether or not flooding will cause damage. The Michigan Department of Environmental Quality (MDEQ) estimates that about 6% of Michigan's land – roughly the size of the southeast Michigan counties of Wayne, Oakland, Macomb, Washtenaw, and Monroe combined – is flood-prone, including about 200,000 buildings. The southern half of the Lower Peninsula contains the areas with the most flood damage potential.

The primary flooding sources include the Great Lakes and connecting waters (Detroit River, St. Clair River, and St. Marys River), thousands of miles of rivers and streams, and hundreds of inland lakes. Michigan is divided into 63 major watersheds, as shown in the map at the end of this section. All of these watersheds experience flooding, although the following watersheds have experienced the most extensive flooding problems or have significant damage potential: 1) Clinton River; 2) Ecorse River; 3) Grand River; 4) Huron River; 5) Kalamazoo River; 6) Muskegon River; 7) Saginaw River; 8) Rifle River; 9) River Raisin; 10) Rouge River; 11) St. Joseph River; and 12) Whitefish River. The flooding is not restricted to the main branches of these rivers, but at the end of this section, a collection of maps displays all of the official floodplains which have been identified and digitized through National Flood Insurance Program-related studies. (More floodplains exist than have been shown on those maps, but many of them have not yet been digitized for processing in Geographic Information Systems. The counties that have no flood information displayed in those maps are ones that have not yet had digital flood boundaries made available in GIS format.)

Most riverine flooding occurs in early spring and is the result of excessive rainfall and/or the combination of rainfall and snowmelt. Ice jams are also a cause of flooding in winter and early spring. Log jams can also cause streams and rivers to be clogged up, and the backed-up waters to overflow the stream's banks. Either ice jams or log jams can cause dangerous flash flooding to occur if the makeshift dam-effect caused by the ice or logs suddenly gives way. Severe thunderstorms may cause flooding during the summer or fall, although these are normally localized and have more impact on watercourses with smaller drainage areas.

A map at the end of this section illustrates the major rivers and watersheds in the state. All of these rivers are susceptible to flooding. Although the flood hazard areas are spread throughout the state, the highest risk zones are in the populated areas of the southern two-thirds of the Lower Peninsula, including the glacial lake bed areas along Lake Erie, Lake St. Clair, and Saginaw Bay. As indicated earlier, the Michigan Department of Environmental Quality estimates that 6% of Michigan's land area, encompassing more than 200,000 buildings, is considered prone to flooding. Nationwide, annual flood losses amount to several billion dollars per year, along with over 140 fatalities on average. The monetary losses continue to rise. Michigan reflects this upward trend, with annual flood-related damages estimated to be between $60 and $100 million. The NCDC tallies shown in the table at the end of this section shows an average of $24 million per year from events significant enough to report on a community level. (Many individual households receive damage in addition to these events, and report only to their insurance companies.)

It is widely known that controlling floodplain development is the key to reducing flood-related damages. Although there are state and local programs to regulate new development or substantial improvements in flood-prone areas, floodplain development in many communities continues to increase, resulting in corresponding increases in potential future flood-related damages. The opportunity to mitigate flood hazards rests primarily with local government, since it controls the regulation or direction of land development. Proper land use management and strict enforcement of building codes can make communities safer from flood hazards and help reduce the high costs of flood losses.

Urban and Other Flooding

Flooding may not always be directly attributable to a river, stream or lake overflowing its banks. Rather, it may simply be the combination of excessive rainfall and/or snowmelt, saturated ground, and inadequate drainage. With no place to go, the water will find the lowest elevations – areas that are often not in a floodplain. That type of flooding is becoming increasingly common in Michigan, as development outstrips the ability of the drainage infrastructure to properly carry and disperse the water flow. Flooding also occurs due to combined storm and sanitary sewers that cannot handle the tremendous flow of water that often accompanies storm events. Typically, the result is water backing into basements, which damages mechanical systems and can create serious public health and safety concerns. Other cases involve the ponding of waters across roads or in other low-lying areas. These additional types of flooding have not been given a separate chapter in this plan, but instead have been included in the descriptions of the Riverine flood hazards within this section.

"Urban flooding" may involve low-lying areas that collect runoff waters even though they are not adjacent to drains or bodies of water. This risk varies with the topography, soil types, runoff rates, drainage basin size, drainage channel sizes, and impervious ground surfaces in each area. Other kinds of urban flooding stem from flaws or shortcomings in existing sewer infrastructure. Some flood events may come from undersized or poorly designed sewer systems that cannot always process the amounts of precipitation and runoff that affects an area. Other events may have less to do with system design than with the collective effects of land use and development trends, illegal diversion of water, or actions that plug storm drains or otherwise interfere with system function. In some cases, flooding may result from power failures that temporarily shut down needed pumps and other facilities. (Backup power systems can be a vital flood mitigation strategy in such cases.) Many communities have been upgrading their drainage systems, separating combined sewer systems (in which storm and sanitary sewer systems share many of the same components), and enforcing local codes, but they vary in the amount of long-term benefits so far realized from these actions.

Some forms of flood damage even come from the decisions of individual homeowners and must be addressed on that level. Proper landscaping and downspout placement can prevent rainwaters from pooling around a structure and seeping into a basement. The use of sump pumps and sewer backflow preventers can prevent a great deal of the damages that are reported each year. Property developers and purchasers should be aware of the possibility of flooding in many areas, and should either locate their homes outside of risk areas, or engineer them to be unaffected by such events. This is an especially important concern in areas that are scenic and desirable because of their riparian locations. Some of these individual-level decisions and risks can be difficult to assess, but should be discussed in the flood analysis section of a plan, to increase public awareness and encourage individuals to be proactive and responsible.

Both urban and riverine flooding tend to be a bit more of a problem in the southern part of the Lower Peninsula, due to the much larger amount of development that exists there. Most parts of the state do have flood risks, however. The upper peninsula often sees an elevated risk of flash flooding from dam failures, while the sprawling developments around the major cities in the southern part of the state have often caused water runoff patterns that severely strain or overwhelm aging drainage infrastructure downstream. The areas that appear to be significantly less at-risk are those on high ground and in headwater locations—also at a relatively high elevation—where waters tend to simply drain to lower-lying areas outside of the community, rather than building up into a local flood problem.

In Michigan, there tends to be a major flood event about every year or two. (A long list of flood events that resulted in disaster declarations follows in this section.) Every year, there are various local flood events that do not rise to the level of a state or federally declared disaster. Occasional deaths and injuries are reported in connection with these events—about one death every two years (not counting shoreline and Great Lakes deaths, which are covered in a separate section that follows) and a slightly larger number of injuries. Property damage is extensive, averaging at least 60 to 100 million dollars per year from major events.

Climate Change Considerations

One of the Michigan trends connected with climate change is to experience increasing amounts of precipitation. Moreover, this precipitation is considered more likely to take the form of acute (and severe) weather events. As mentioned in the winter weather sections, a larger proportion of snow precipitation occurring in snowstorm events can cause more extensive snow accumulation which, under unlucky temperature patterns, may add to the drainage burdens of the normal melting and rainfall patterns of the spring season. In short, spring flood risks are likely to worsen, as are ice jam related winter flood risks.

Impact on the Public

Riverine flooding has caused displacement, property damage, and impacts on the health of residents. In some cases, utility providers have had facilities located in floodplain areas, and these facilities have been negatively impacted by flooding. Floodwaters can also prevent normal access to structures and facilities. Flooding is a hazard whose risks are routinely underestimated by the public, who may be inclined to attempt to walk or drive through shallow waters, or to allow their children and pets to play in the water as if it were part of a beach or swimming pool. Public education is vital so that there is widespread knowledge of the contaminants and germs that floodwaters contain, and a greater awareness of the risks that floodwaters pose to drivers and pedestrians. Drivers need to know that roads and bridges are often weakened and degraded by flood impacts, and that the road they assume is still there under shallow waters may no longer be intact. Less than a foot of flowing water can cause travelers to end up in a ditch or sinkhole, where persons may find that it is impossible to escape from a submerged vehicle under the pressures exerted by flowing water. Those who are tempted to walk through floodwaters should be informed that the waters tend to conceal the presence of open manholes and dangerous debris, such as rusty nails and metal, or live electrical wires that can cause harmful shocks.

Impact on Public Confidence in State Governance

In cases where any type of flood impact causes negative effects on structures, utilities, or the ability to access them, doubts can arise about the appropriateness of the planning and development mechanisms that may have allowed these flood impacts to occur. Doubts may also arise about the adequacy of the area's drainage infrastructure, whether in the form of channels/drains at the surface or storm sewer systems underneath the ground. Especially controversial are cases in which sewer systems are perceived to have caused basement flooding, and when the original designs of some sewer systems have had their capacities exceeded because of subsequent urban development trends, or when outmoded designs have caused waters to be contaminated with sewage. Public health issues in these cases can thus compound the problems caused by flooding itself, in ways that can seem to be attributable to government.

Impact on Responders

"Ordinary" flood waters in known floodplain areas and riparian lands often contain "hidden" hazards that may not be evident at first. Roads and bridges are often weakened and degraded by flood impacts, and a previously intact roadway area may have been eroded away under a seemingly shallow water surface. Floodwaters tend to conceal the presence of open manholes, dangerous debris (such as rusty nails and metal), and live electrical wires that can cause harmful shocks. Responders in a large flood event therefore deal with numerous hidden hazards as well as floodwaters that are often unclean (containing carcasses, garbage, and filth) and contaminated with chemicals (from area roads, cars, industrial sites, storage facilities, etc.).

Impact on the Environment

Flooding is generally part of a natural cycle that has many important and beneficial functions for the environment. Flooding raises the water table in wetlands, maintains biodiversity, and replenishes nutrients back into the soil. Additionally, higher water tables allow fish and water plants to recolonize and may also help to control some invasive species. Flooding, however, becomes a problem in the built environment. Drainage systems and city sewers can become overwhelmed, causing raw sewage to back up in basements and onto roadways. Flooding in urban areas can also cause increased runoff, which may carry pollutants through storm sewers into rivers and lakes. Urban runoff can be toxic, as it may contain garbage, fertilizers, oil and other residues from city streets.

Significant Riverine Floods

Michigan has experienced 12 flood disasters since 1975 which resulted in both a Presidential Major Disaster Declaration and a Governor's Disaster Declaration (opening up the full range of federal and state supplemental disaster

assistance). A slightly lower number of additional events have resulted only in a Governor's Disaster Declaration (activating state supplemental and limited federal disaster assistance). Combined, these flood disasters have caused hundreds of millions of dollars in damage to homes, businesses, personal property, and agriculture. The following are brief synopses of these and other Michigan flood events in the past few decades, and they do include some "urban flood" events in addition to the traditional riverine floods. Many other damaging flood events have occurred at the local level, without qualifying for a governor's disaster declaration, and some of these are included in the following descriptions.

Partial Listing of Significant Flood Events in Michigan

March 24-27, 1904 - Central and Southern Lower Michigan

One of the most disastrous and extensive floods ever to occur in Michigan struck the central and southern Lower Peninsula during March 24-27, 1904. The flooding was caused by runoff resulting from intense rainfall, compounded by heavy snowpack and frozen soils. The flooding was most prevalent in the Grand, Kalamazoo, Saginaw and River Raisin basins, and to a lesser extent in the Huron and St. Joseph River basins. (The flood peaks from this flood are still the highest associated with spring flooding in the southern Lower Peninsula since recordkeeping began.) Damage was widespread and severe. In Grand Rapids, the flooding caused 14,000 persons to be homeless and damaged 2,500 homes and 30 businesses. Damage was estimated at $2 million. In Lansing, the flood was the most extensive in 135 years of local history. One fatality was reported, and damage was $200,000. In Bay City, numerous dams were undermined or washed away, and highway and railroad bridges were damaged – forcing a halt to railroad traffic. In Kalamazoo, a two square mile area was inundated, with damages estimated at $50,000.

April 4-11, 1947 - Central and Eastern Lower Michigan

The flood of April 4-11, 1947 was caused by a combination of snow and rainfall that began in late March of that year. In early April, two frontal systems dumped several inches of rain in many localities across central and eastern Lower Michigan. The areas primarily affected by the April, 1947 flood included the Clinton, Detroit, Grand, Kalamazoo, Saginaw and St. Clair Rivers, and the River Rouge. The city of Flint was particularly hard hit, with damage totaling $4 million. Damage was also significant in Northville, where floodwaters filled basements and inundated first floors of numerous residences.

April 24-26 and May 7-12, 1960 - Upper Peninsula

Record floods were widespread in the Upper Peninsula on April 24-26 and May 7-12, 1960. The April flood affected primarily the Montreal, Black and Presque Isle River basins in the western Upper Peninsula. The May flood affected the Manistique River basin in the central and eastern Upper Peninsula. Intense rainfall contributed to both flood events. Rainfall was 3-5 inches during April 24-26 and 4-6 inches during May 6-12. The size of the area covered by flooding was significant, but the damage was not. Because the area was neither densely populated nor developed, flood losses to residences, businesses, and public roadways and bridges were limited to $575,000.

December 1972 – Lower Peninsula (Federal Disaster #363 – 9 counties)

A series of severe storms produced a great deal of precipitation during the Spring thaw season. The resulting floods resulted in a federal disaster declaration for a set of counties in the southeastern two-thirds of the Lower Peninsula, stretching from Iosco County, at the northeastern extreme, down to Berrien County at the southwestern state boundary, with Arenac and Bay Counties in between. Another affected area was the "thumb" and metropolitan area of Wayne, Monroe, and Macomb Counties, on the south, and Tuscola and St. Clair Counties, farther north. Every one of these nine counties would soon face another flood disaster merely four months later, as the Spring season arrived with its snow thaws (see below).

April 1973 – Lower Peninsula (Federal Disaster #371 – 14 counties)

A series of severe storms produced a great deal of precipitation during the Spring thaw season. The resulting floods resulted in a major disaster declaration for 14 counties across much of the Lower Peninsula—from Iosco to Berrien, and from Huron County down to Wayne County. Most of the "thumb" and Detroit Metropolitan regions were heavily affected, as was the Upper Peninsula county of Menominee. Many of these same southeastern and Saginaw Bay area counties had been affected by the December 1972 event just a few months before.

April 1975 – Southern Lower Michigan (Federal Disaster #465 – 21 counties)

A series of intense thunderstorms struck southern Lower Michigan in the last two weeks of April 1975, spawning several tornadoes and causing widespread flooding over a 21 county area. Total public and private damage was nearly $58 million. A Presidential Major Disaster Declaration was granted for the 21 affected counties.

September 1975 – West Central / Central Lower Michigan (Federal Disaster #486 – 16 counties)

During the last week of August and first week of September 1975, intense thunderstorms and severe winds pounded a 16 county area in west-central and central Lower Michigan. Intense rainfall accompanying these storms caused widespread flooding, resulting in nearly $3 million in public and private damage. A Presidential Major Disaster Declaration was granted for the 16 affected counties.

March 1982 – Berrien and Monroe Counties (Federal Disaster #654)

In March 1982 a combination of heavy rainfall and melting snow resulted in a flood disaster in Berrien and Monroe counties. Damage from that event was estimated at $12 million. One death was directly attributed to the flood conditions. A Presidential Major Disaster Declaration was granted for the two affected counties.

September 1985 – East Central Michigan (Federal Disaster #744 – 6 counties)

A year earlier, on September 5, 1985 severe thunderstorms struck east central Michigan, resulting in flooding in a six county area. As much as 7.45 inches of rain fell in Genesee County, which was hardest hit. The heavy rainfall caused flash flooding in many areas. Damage occurred primarily from overbank flooding on major rivers and streams. In addition, widespread flooding occurred in residential areas due to overburdened stormwater drainage systems. Over 2,500 homes were damaged, many roads were washed out and bridges damaged, and extensive agricultural damage occurred. Total public and private damage was estimated at $63 million. A Presidential Major Disaster Declaration was granted for the six counties.

September 1986 – Central Lower Michigan (Federal Disaster #774 – 30 counties)

Beginning on September 10, 1986 a slow moving low-pressure system moved across the middle of the Lower Peninsula. In a 24-hour period, the intense rainstorm produced rainfall ranging from 8 to 17 inches over an area 60 miles wide and 180 miles long. In Big Rapids, 19" of rain fell from September 9 to 12. The storm resulted in thousands of people being evacuated due to flooding. Five people were killed and 89 injured. (Up to ten were killed, if indirect effects are included.) About 30,000 homes suffered basement and structural damage and 3,600 miles of roadways were impassable as a result of the failure of four primary bridges and hundreds of secondary road bridges and culverts. The heavy rainfall resulted in 11 dam failures and 19 others that threatened with failure. Over $300 million in damage resulted from the flood. This was the worst flood in Michigan in 50 years. Thirty (30) counties were included in the Presidential Major Disaster Declaration granted for this flood.

June 1989 – Branch, St. Joseph, and Kalamazoo Counties

Heavy rainfall from May 31 to June 4, 1989 caused widespread flooding in Branch, St. Joseph and Kalamazoo counties. Over 400 homes incurred flood damage and many local roads washed out. (The storms also caused significant wind damage in some areas, particularly in the village of Manchester in Washtenaw County.) A Governor's Disaster Declaration was granted to provide assistance to the counties. In addition, SBA low-interest disaster loans were made available to home and business owners in the affected counties to help repair flood and wind-related damages.

July 1992 – Gogebic County

On July 2 and 3, 1992 severe storms struck Gogebic County, dumping over six inches of rain in a 24-hour period. The stormwater runoff caused creeks and rivers to overflow, causing severe damage to the road system throughout the county. Culverts were washed out, roads washed away, bridges were clogged with debris, and numerous residents were stranded because they could not use the road systems. Several road washouts were particularly severe – as much as 16-20 feet deep. The conditions were determined to be a serious threat to life safety and essential services. A Governor's Disaster Declaration was granted to provide assistance to the county in repairing the road washouts and clearing debris.

April 1993 – Shiawassee County

Flash flooding caused by heavy rains occurred in Rush and Hazelton Townships in Shiawassee County on April 21, 1993. The flooding caused widespread and severe washouts and structural damage to roads and bridges, greatly hampering the ability of emergency vehicles to provide timely emergency response to many parts of the county. As a result, the Governor granted a Disaster Declaration to the county to provide supplemental state assistance in repairing the damage and opening up the roads.

July 1994 – Lapeer, Sanilac, and Tuscola Counties

Heavy rains caused flash flooding in the counties of Lapeer, Sanilac and Tuscola on July 7-8, 1994. The flooding was widespread and caused severe damage to roads, drainage systems, and several homes. Saginaw County also suffered some storm-related damage, but to a lesser extent than the other three counties. Total public damage in Lapeer, Sanilac and Tuscola counties exceeded $1 million. Ninety-three homes incurred some level of damage. A Governor's Disaster Declaration was granted on July 8, 1994 to provide supplemental state assistance in the recovery.

April 1996 – Western/Southern Upper Peninsula

The melting of a heavy snow pack combined with rain during the second half of April and caused many streams and rivers to flood—especially in Menominee, Iron, and Delta Counties. The flooding inundated and washed out several roads and bridges, flooded many yards and basements, and caused nearly $2 million in public damages. Up to 24 roads were closed off at the height of the flood event.

May 1996 – Berrien County

On May 10, 1996 heavy rain in southern Berrien County caused widespread flash flooding that damaged nearly 100 miles of roadway (20 miles incurred severe damage) and numerous culverts, caused bridge washouts, collapsed basements, and undermined a railroad track. In addition, a dam in danger of overflowing had to be systematically drained by the Michigan Department of Environmental Quality and the U.S. Army Corps of Engineers. Public damage was estimated at $250,000. A Governor's Disaster Declaration was granted on May 22, 1996 to provide supplemental state assistance with the road, bridge, culvert and dam repairs. In addition, SBA low-interest disaster loans were made available to home and business owners that suffered uninsured damage from the flooding.

June 1996 – Thumb Area (Federal Disaster #1128 – 7 counties)

From June 21-23, 1996, intense thunderstorms producing heavy rainfall caused widespread and severe flooding in east central Michigan (the Thumb area). Some areas received over five inches of rain in a four to five hour period, which quickly outstripped the ability of the public drainage and sewer systems to handle the massive amounts of water runoff. The result was widespread flash flooding that caused numerous road and bridge washouts, culvert failures, damage to drainage channels, and damage to over 2,700 homes and 40 businesses. These storms also spawned a tornado that struck the city of Frankenmuth in Saginaw County, destroying six homes and one business, and damaging another 108 homes and nine businesses. The total public and private damage exceeded $25 million, most of which was flood-related. A Presidential Major Disaster Declaration was granted for the seven counties most heavily impacted by the storms and flooding.

June 1997 – West Michigan

On June 20-21, 1997 a series of intense thunderstorms passed through West Michigan, spawning heavy rainfall that flooded many areas in Allegan, Ottawa, Barry, and Van Buren counties. Flood and wind damage was particularly severe in Allegan County, which reported four injuries, five homes destroyed and 234 damaged, and 37 businesses damaged. Damage to public facilities, roads and bridges, and culverts and drainage channels totaled nearly $1.5 million. Ottawa County officials reported damage to 111 homes and five businesses, in addition to nearly $700,000 in public damages. On June 27, 1997, a Governor's Disaster Declaration was granted to Allegan and Ottawa counties to provide supplemental state assistance for the public damage. The SBA provided low-interest disaster loans to those home and business owners that suffered uninsured damage from the flooding or wind.

July 1997 – Southeastern Michigan (Federal Disaster #1181 – 6 counties)

On July 2, 1997 a series of intense thunderstorms struck central and southeast Michigan, causing extensive wind damage. A Presidential Major Disaster Declaration was granted for five counties, primarily for the wind-related damage. However, the heavy rainfall produced by these storms caused flooding in Wayne and Macomb counties. Flood-related damage to the public water and sewer systems in those two counties totaled nearly $300,000. It should be noted that these flooding problems occurred at the same time the two counties were also faced with flooding problems associated with high water levels on the Great Lakes.

February 1998 – Southeast Michigan

Heavy rain, averaging almost 3 inches across many locations, caused flooding to occur in Wayne and Monroe Counties. (Three inches of rain is more than Detroit's average for the entire month of February.) The hardest-hit locations were in eastern Monroe County, where lakeshore flooding exacerbated the area's water runoff problems. East winds gusted to as high as 45mph, causing the Lake Erie water level to rise 3.5 feet above normal at Luna Pier and flooding many roads along the lakeshore. This event was topped by six-foot waves during the night of February 17th. The high water and pounding surf destroyed two private docks and prevented effective runoff further inland. Reports of basement and road flooding came in from all over Monroe County. Urban flooding was also significant in parts of Wayne County—hundreds of basements and many streets were flooded in cities around Detroit (especially Taylor, Dearborn Heights, Westland, and Grosse Ile), and a state of emergency was declared for much of the county. High water briefly closed the Southfield Freeway just north of Interstate 94 (in Dearborn). In Macomb County, the communities of Warren, St. Clair Shores, and Clinton Township also experienced urban and lowland flooding. Total damage exceeded $1 million.

April 1998 – Alpena County

Rapid snowmelt, combined with intense rainfall that began on March 30, 1998 and continued through April 2, resulted in severe flooding in the northeast portion of Alpena County. The flooding forced residents of 80 homes in one subdivision in the city of Alpena to be evacuated. A total of 221 homes and five businesses were damaged by the floodwaters. Public damage totaled over $700,000. A Governor's Emergency Declaration was granted to provide supplemental state assistance to the county. In addition, a Small Business Administration (SBA) Declaration was also granted that provided low-interest disaster loans to the home and business owners impacted by the flooding.

September 2000 – Wayne and Oakland Counties (Federal Disaster #1346)

A Presidential Major Disaster Declaration was granted to Wayne and Oakland Counties for urban flooding and sewer backups caused by intense rainfall on September 10 and 11, 2000. Although much damage took the form of basement flooding, which is not the type of flooding that is normally easy to see and broadcast through the mass media, this was one of the largest Michigan disasters ever to occur, in terms of the sheer amounts of documented damages to homes in Detroit and its surrounding cities. More details can be found in the report included as a part of the Michigan Hazard Mitigation Plan, in Attachment F. The event

was denoted as federal disaster number 1346, and hazard mitigation funds made available to Michigan as a result of this disaster were instrumental in allowing local hazard mitigation plans to be developed in most areas of the state.

February 2001 – Genesee County

Heavy rainfall and melting snow in parts of Southern Lower Michigan on February 9-10, 2001 caused flooding in many areas, but particularly in Genesee County. The worst flooding occurred in the southern half of Genesee County, where damage to roads, drains and other public facilities was extensive. Two major pumping stations were damaged by the flooding, resulting in estimated repair costs in excess of $7 million. Repair and floodfighting costs for the County Drain Commission totaled nearly $600,000, and the County Road Commission incurred an additional $1.8 million in flood-related damages and costs. The flooding also caused damage to dozens of homes and forced the evacuation of a 200-resident mobile home park. A Governor's Disaster Declaration was granted to provide supplemental state assistance to the county for public facility damages and costs. In addition, a Small Business Administration (SBA) Declaration was also granted that provided low-interest disaster loans to the home owners impacted by the flooding. (In addition to the damage in Genesee County, this flood event also caused damage to several hundred homes in Lansing and threatened to overtop the Shiawassee town Dam in Shiawassee County and the Peninsular Paper Dam in Ypsilanti. Fortunately, local and state officials were able to take steps to stabilize both dams and mitigate the threat of collapse.)

February 10-13, 2001 – Monroe County

Although Monroe County flood damage estimates were fairly low (mostly from flooded basements) during this event involving the cresting of the River Raisin, the incident is noteworthy because it was fatal to three young persons who drowned when their pickup truck attempted to cross a flooded road (near the Saline River) and ended up in a ditch filled with 10 feet of water. A fourth person in the truck was the only one able to escape, by squeezing out of a rear passenger window and swimming to safety.

April 2002 – Western Upper Peninsula (Federal Disaster #1413 – 6 counties)

In 2002, record-setting snowfall in February and March set the stage for flooding in April. During February and March of 2002, the north-central and western parts of Upper Michigan received over 100 inches of snowfall. The snow pack held over 11 inches of water. The snow quickly melted during a six day period (April 11-17), releasing all that water into creeks, streams, rivers and lakes. To heighten the situation, over two inches of rainfall occurred between April 10-12 over much of Upper Michigan, and record high temperatures in the 70s and 80s were recorded on the 15th and 16th. During those two days, a dramatic snow melt occurred with nearly two feet of snow melting away. To complicate matters further, moderate rain during the morning of the 18th and severe thunderstorms in the afternoon and evening dumped up to an additional 1½ inches of water over an already saturated and flooded Upper Peninsula. Following the rain and warm temperatures, streams and rivers began to rise and overflow. Many local and county roads were closed due to high water and several dams were in jeopardy of failing. Localized flooding of low-lying areas was common across the western and central Upper Peninsula. Major flooding on rivers and lakes occurred in eight Upper Michigan counties. Approximately 160 homes and businesses were affected by the rising waters. Major highways US-2, M-28, and M-64 were closed and 25 local and county roads were also closed due to high water. The Black, Montreal and Ontonagon Rivers all went above flood stage. A partial failure of the Presque Isle Wildlife Dam occurred on the Presque Isle River. Heavy rains and rapid melting of the snow pack contributed to the collapse of a 10 feet wide section of the earthen portion of the dam. The total cost of the flooding was estimated at $18.5 million. A Presidential Major Disaster Declaration was granted to six counties in the Upper Peninsula.

May 2003 – Marquette County

When the Mother's Day storm runoff from the Huron Mountains overwhelmed a dike holding back Silver Lake in northwest Marquette County, a wave of water inundated the Dead River basin all the way to Lake Superior in Marquette. A number of roads and bridges were washed out by the flood waters. An evacuation order was issued for about 1,800 people. The Presque Isle Power Plant at the Upper Harbor in Marquette was flooded and shut down for a number of days, resulting in shortages of electricity across western and central Upper Michigan. A Governor's Emergency Declaration was issued for Marquette County.

May-June 2004 – Southern Lower Michigan (Federal Disaster #1527 – 23 counties)

In May 2004, a stationary front over Iowa, Wisconsin, and Michigan brought severe thunderstorms and heavy rains, which caused widespread flooding over Southern Lower Michigan. Much of the rainfall occurred in saturated areas that had experienced well-above average precipitation for the month of May. Over a 36 hour period (12 am May 22nd to 8 am May 23rd), 2 to 6 inches of rain fell across Southeast Michigan. Backyards were submerged under several feet of water. About 100 homes in Macomb County had damage of about $100,000 each. Road and bridge damage was expected to cost $10 million to repair. Total rainfall over the Grand River basin from May 20th through June 3rd varied from four to as much as seven inches. It was the biggest and longest duration flooding event in the past ten to twenty years across southwestern and south central Lower Michigan. It was the wettest May on record in Lansing and Muskegon and the third wettest May on record in Grand Rapids. A Presidential Major Disaster Declaration was granted to 23 counties in the southern Lower Peninsula.

June 2008 – Lower Peninsula (Federal Disaster #1777 – 12 counties)

Beginning on June 6, severe weather impacted twelve counties and two major population centers in the southwest and central Lower Peninsula. The National Weather Service reported two flash floods that exceeded the "100-year" threshold, confirmed three EF1 tornadoes, and also noted severe thunderstorms with winds exceeding 100 mph. Rainfall totals were estimated between 7 and 12 inches, exceeding the "100-year" rainfall values of 3.5 inches in less than 6 hours. Flash flooding washed out roads, flooded crops, and caused moderate flooding of rivers and streams. A large severe thunderstorm squall line affected Southwest Michigan on June 8, with four counties experiencing winds of 75 to 100 mph. Disaster declarations were requested and received in July, for 11 full counties. Some of the worst damages were noted in Mason County ($3 million in property damage and $½ million in crop damage), Lake County ($2 million in property damage and $½ million in crop damage), Osceola County ($1 million in property damage and $¼ million in crop damage), Manistee County (nearly $1 million in property damage), and Wexford County (about $¾ million in property damage).

September 2008 – Southern Lower Peninsula

Excessive rainfall which started on September 13th resulted in extensive flooding over many days following. Many roads in the city of Kalamazoo were closed for several days, and damage to public infrastructure (mostly roads and bridges) was estimated at $11 million. At Augusta, the total rainfall was reported as 10.5 inches. A state of emergency was declared in Kalamazoo County—466 homes in the City of Kalamazoo were flooded, along with ten businesses. Surrounding counties were less extensively damaged, with Berrien County suffering about $750,000 in damage, and $½ million estimated for each of the counties of St. Joseph, Cass, and Oakland, and lesser amounts for the counties of St. Clair, Lapeer, Saginaw, Washtenaw, Wayne, Livingston, and Macomb.

June 2009 – Southwest Michigan (Ottawa and Allegan Counties)

After thunderstorms with heavy rainfall moved in from Lake Michigan, already saturated ground resulted in flooding that damaged numerous homes and streets, estimated at more than 2,000 homes damaged in some way, and 57 damaged or washed-out roads. A local state of emergency was declared in Ottawa County, where total damages were estimated at $34 million. In neighboring Allegan County, about $4 million in damage was estimated.

May 2012 – Heavy Rains and Flash Flood (Genesee and Shiawassee Counties)

Half a foot of rain fell on the Flint area during May 4, causing cars to be stranded on roadways, evacuation of some residents by boat, numerous roads shut down (including sections of Interstates 75 and 69), and some bridges to be washed out. In Genesee County, property damage totaled $7.1 million and the City of Swartz Creek and Township of Flint were particularly hard-hit. An apartment building, near Hill Road in Grand Blanc Township, saw $1.7 million in damage and had to be evacuated as electric power was taken out and 30 cars were nearly submerged. In neighboring Shiawassee County, about $1.1 million in property damage occurred.

April-May 2013 – Western Lower and Upper Peninsulas (Federal Disaster #4121 – 16 counties)

Record flooding occurred during the month of April, most directly caused by an accumulation of heavy rains and resulting in disaster declarations for numerous counties across the western portions of the state (plus the cities of Grand Rapids and Ionia, which were both specifically named in the Governor's disaster

declaration). Hundreds of homes were flooded, more than 300 roads were closed, and the preliminary damage assessments totaled more than 32 million dollars. The flooding was exacerbated by the melting of significant snowpack—especially in the Western and Central Upper Peninsula. According to the NCDC website in 2014, the following damage amounts were sustained by each of the following counties: $5 million in Allegan, $5 million in Barry, $5 million in Calhoun, $3 million in Clare, $5 million in Clinton, $3 million in Eaton, $1 million in Gogebic, $3 million in Gratiot, $2.9 million in Houghton, $5 million in Ingham, $7 million in Ionia, $3 million in Isabella, $3 million in Jackson, $5 million in Kalamazoo, $3 million in Lake, $625,000 in Marquette, $3 million in Mason, $3 million in Mecosta, $1.4 million in Midland, $3 million in Montcalm, $5 million in Muskegon, $5 million in Newaygo, $3 million in Oceana, $550,000 in Ontonagon, $3 million in Osceola, $5 million in Ottawa, $1.3 million in Saginaw, and $3 million in Van Buren.

It is important to remember that the majority of riverine floods in Michigan do not result in a Governor's or Presidential Disaster Declaration. An example was the flooding that occurred due to an ice jam on the Grand River in Robinson Township, Ottawa County, beginning on February 24, 1994 and continuing until the ice jam broke free on March 5. During that 10-day period, floodwaters damaged 45 homes and three businesses and caused the evacuation of 125 people from their homes until the waters receded. Sections of three county roads and a county park also sustained damage. The County formally requested a Governor's Disaster Declaration, but unfortunately there was little that could be done in the way of state assistance to help in the response and recovery to that particular event. However, the Governor did request, and receive, an SBA Disaster Declaration which made available low-interest disaster loans to those home and business owners that suffered uninsured losses in the flood.

This same area was affected by another ice jam in January 2005, causing the evacuation of about 50 homes. The area remained flooded for several days, as a prolonged cold spell slowed the flood water's retreat. The flooding, which occurred about 20 miles west of Grand Rapids, affected homes in two Robinson Township neighborhoods. At least one road was covered by three feet of water. The river usually runs about 10 feet in the area during that time of the year, but during the morning of the flood the water level had risen to 17.6 feet, which is 4.3 feet above flood stage. A state of emergency was declared in the township, but no Governor's or Presidential declaration was issued. However, the county did qualify again for the Small Business Administration's low interest disaster loans. Due to repeated flooding, the township is using Pre-Disaster Mitigation Program (PDMP) money to purchase up to 40 structures and 20 vacant parcels along the floodplain of the Grand River.

A similar example occurred on September 22-23, 2000 in Genesee County, when heavy rainfall caused the flooding of Thread Creek and inundated the city of Grand Blanc's storm and sanitary sewer systems as well as Genesee County's secondary sewer system. The flooding damaged nearly 50 homes and businesses. The Governor requested, and received, an SBA Disaster Declaration for this event, making low-interest disaster loans available to affected residents in Genesee County and the contiguous counties of Lapeer, Livingston, Oakland, Saginaw, Shiawassee, and Tuscola.

More recently, $11 million in flood damages were estimated from a September 2008 event around Comstock, in Kalamazoo County. An additional $5.25 million in flood damages were estimated in various statewide locations from the same September 2008 weather event. Part of the heavy rain was due to the remnants of Hurricane Ike. In December of 2008, about $3.6 million in flood damages occurred in Ottawa County. These events resulted in county emergency declarations. In March 2009, about $3 million in flood damages occurred along the River Raisin, in Monroe County. In June 2009, about $34 million in flood damages occurred to some 2,000 homes in Ottawa County, and $4 million in flood damages occurred in neighboring Allegan County. Both counties declared local states of emergency. August 2009, flooding took place in the southeastern part of Lapeer County, resulting in about $3 million in damage and the closure of M-53 for about 10 days, due to the highway being washed out. In August 2010, Mt. Pleasant experienced significant flooding and about $4 million in damages, including the partial flooding of the Central Michigan Community Hospital.

It is estimated that flood damages in Michigan average at least $60 million to $100 million per year. Only a fraction of those costs are covered under the flood insurance policies of the National Flood Insurance Program (over $1 million per year), and most of the rest seems to be absorbed out-of-pocket by individuals and communities. There are still no known sources of comprehensive flood information for Michigan. The NCDC database lists about $330 million in Michigan flood damages between 1993 and 2010 (an average of nearly $19 million per year), but it is known (from local planning efforts, project applications, and Michigan disaster declarations) that there are a great many local events that are not reported in that database. This plan has therefore focused upon disaster-level flood events. Much more study is needed to build a comprehensive understanding of all vulnerable areas within Michigan. Even the extensive flood mapping efforts do not cover all the possibilities that could arise from blocked drains, ice jams, low-lying areas, and infrastructure failures.

Programs and Initiatives

USGS Water Watch
This web-based service provides real-time monitoring of stream gauge stations across the state. Each station can also be clicked on to obtain historical and statistical records. The web address is http://waterwatch.usgs.gov/new/.

The USGS "Water Alert" program
This service started in August of 2010 and is publicly available, with a website located at http://water.usgs.gov/wateralert/. The program enables users to elect to receive text messages and/or e-mails for any USGS stream gauge stations, when certain flow and water-quality conditions are observed. This program goes a bit beyond the services provided by the National Weather Service by allowing the user to set his or her own criteria for notification. This is useful for alerting users about the onset of a flood, or about a pre-flood stage that can allow advance actions to be taken to prepare and respond. It also offers some users the capacity to make inferences about stream locations beyond those in the existing list of official NWS flood forecast locations.

National Weather Service Doppler Radar
The National Weather Service has completed a major modernization program designed to improve the quality and reliability of weather forecasting. The keystone of this improvement is Doppler Weather Surveillance Radar, which can more easily detect severe weather events that threaten life and property – including weather events that can lead to riverine flooding. Most important, the lead-time and specificity of warnings for severe weather have improved significantly.

National Weather Service Watches/Warnings
The National Weather Service issues flood watches and flood warnings when conditions are right for flooding. A flood watch indicates meteorological conditions are conducive to flooding. People in the watch area are instructed to stay tuned to local radio or television stations for updates on flooding and weather conditions. When flooding is imminent, a flood warning is issued. The warning will identify the anticipated time, level and duration of flooding. Persons in areas that will be flooded are instructed to take appropriate protective actions, up to and including evacuation of family members and removal or elevation of valuable personal property.

The State and local government agencies are warned via the Law Enforcement Information Network (LEIN), National Oceanic and Atmospheric Administration (NOAA) weather radio, and the Emergency Managers Weather Information Network (EMWIN). Public warning is provided through the Emergency Alert System (EAS). The National Weather Service stations in Michigan transmit information directly to radio and television stations, which in turn pass the warning on to the public. The National Weather Service also provides detailed warning information on the Internet, through the Interactive Weather Information Network (IWIN).

Severe Weather Awareness Week
Each spring, the Emergency Management and Homeland Security Division, Michigan Department of State Police, in conjunction with the Michigan Committee for Severe Weather Awareness, sponsors Severe Weather Awareness Week. This annual public information campaign focuses on severe weather hazards such as tornadoes, thunderstorms, lightning, hail, high winds, and flooding. Informational materials on flooding and the other severe weather hazards are disseminated to schools, hospitals, nursing homes, other interested community groups and facilities, and the general public.

Map Modernization Program
The Federal Emergency Management Agency (FEMA) is continuing its program to update the nation's floodplain maps. This program is commonly referred to as Map Mod. The MDEQ is collaborating with FEMA in this effort through the Cooperating Technical Partners (CTP) Program. The MDEQ is playing an integral role in the mapping program by performing studies, reviewing studies prepared by others, and overseeing the mapping effort in Michigan. More information about the Map Modernization effort is at http://www.fema.gov/plan/prevent/fhm/mm_main.shtm.

Once FEMA has completed its production of new digital flood insurance rate maps for a county, the communities within the county will need to consider formal adoption of the new maps to either become eligible to join the NFIP or

to maintain participation. The MDEQ has developed model documents for communities to use for the adoption process. Those documents and further discussion can be viewed and accessed on the NFIP Map Modernization Map Adoption page. Digital maps can be acquired or perused at FEMA's online Map Service Center.
http://www.msc.fema.gov/webapp/wcs/stores/servlet/FemaWelcomeView?storeId=10001&catalogId=10001&langId=-1&userType=G

Michigan Flood Hazard Regulatory Authorities:

Land Division Act, 1996 PA 591, as amended by 1997 PA 87 – The Land Division Act governs the subdivision of land in Michigan. The Act requires review at local, county and state levels to ensure that the land being subdivided is suitable for development. From a flood-hazard viewpoint, a proposed subdivision is reviewed for proper drainage by the County Drain Commissioner, and for floodplain impacts by the MDEQ, Water Resources Division.

Provisions of the Act and its Administrative Rules require that the floodplain limits be defined and prescribe minimum standards for new residential developments in areas within or affected by a floodplain. Restrictive deed covenants, filed with the final plat, stipulate that any building used or capable of being used for residential purposes in areas within or affected by a floodplain shall meet the following conditions:

- Be located on a lot having a buildable site of 3,000 square feet of area with its natural elevation above the floodplain limit. (Lots with less than 3,000 square feet of buildable area above the floodplain may be filled to achieve that area.)
- Be served by streets within the proposed subdivision that have surfaces no lower than one foot below the elevation defining the floodplain limits.
- Have lower floors, excluding engineered basements, that are not lower than the elevation defining the floodplain limits. (The Michigan Building Code requires the lowest floor to be at least one foot above the 1% annual chance flood elevation level, and this requirement includes regular basements.)
- Have openings into the basement that are not lower than the elevation defining the floodplain limits.
- Have basement walls and floors that are below the elevation defining the floodplain limits made watertight and designed to withstand hydrostatic pressures.
- Be equipped with a positive means of preventing backup from sewer lines and drains serving the building.
- Be properly anchored to prevent flotation.

Floodplain Regulatory Authority, found in Water Resources, Part 31 of the Natural Resources and Environmental Act, 1994 PA 451, as amended – The floodplain regulatory portion of Act 451 regulates residential occupation of high-risk flood hazard areas and ensures that other uses do not obstruct flood flows. A permit is required from the MDEQ for any occupation or alteration of the 100-year floodplain. In general, construction and fill may be permitted in the portions of the floodplain that are not floodway, provided local ordinances and building standards are met. (Floodways are the channel of a river or stream and those portions of the floodplain adjoining the channel that are reasonably required to carry and discharge a 100-year flood. These are areas of moving water during floods.) New residential construction is specifically prohibited in the floodway. Non-residential construction may be permitted in the floodway, although a hydraulic analysis may be required to demonstrate that the proposed construction will not harmfully affect the stage-discharge characteristics of the watercourse.

The Act does not apply to watersheds that have a drainage area of less than two square miles. (Those small watersheds are considered to be local drainage systems, and do not fall under the Floodplain Regulatory Authority.)

Soil Erosion and Sedimentation Control, Part 91 of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended – This portion of the Act seeks to control soil erosion and protect the waters of the state from sedimentation. A permit is required for all earth changes that disturb one or more acres of land, as well as those earth changes that are within 500 feet of a lake or stream. The Act itself does not address flood hazards, per se. However, if sedimentation is not controlled, it can clog streams, block culverts, and result in continual flooding and drain maintenance problems.

Inland Lakes and Streams, Part 301 of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended – This portion of the Act regulates all construction, excavation, and commercial marina operations on the State's inland waters. It ensures that proposed actions do not adversely affect inland lakes, streams, connecting waters

and the uses of all such waters. Structures are prohibited that interfere with the navigation and/or natural flow of an inland lake or stream. Though reduction of flooding is not a specific goal of this Act, minimizing restrictions on a stream can help to reduce flooding conditions.

Wetlands Protection, Part 303 of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended – This portion of the Act requires a permit from the Department of Environmental Quality for any dredging, filling, draining or alteration of a wetland. This permitting process helps preserve, manage, and protect wetlands and the public functions they provide – including flood and storm water runoff control. The hydrologic absorption and storage capacity of wetlands allows them to serve as natural floodwater and sedimentation storage areas. The Act recognizes that the elimination of wetland areas can result in increased downstream flood discharges and an increase in flood damage. Permits for wetland alterations are generally not issued unless there is no feasible alternative and the applicant can demonstrate that the proposal would not have a detrimental impact upon the wetland's functions.

Natural Rivers Program, Part 305 of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended – The Natural Rivers Act was originally passed in 1970, and has been incorporated as Part 305 of the Natural Resources and Environmental Protection Act. The purpose of this program is to establish and maintain a system of outstanding rivers in Michigan, and to preserve, protect, and enhance their multi-faceted values. Through the natural rivers designation process, a Natural River District is established (typically 400 feet either side of the riverbank) and a zoning ordinance is adopted. Within the Natural River District, permits are required for building construction, land alteration, platting of lots, cutting of vegetation, and bridge construction. Not all of the zoning ordinances on the natural rivers have the same requirements, but they all have building setback and vegetative strip requirements. Although the purpose is not specifically to reduce flood losses, by requiring building setbacks (in many cases prohibiting construction in the 100-year floodplain), flood hazard mitigation benefits can be realized.

Dam Safety, Part 315 of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended – The Dam Safety Unit within the Land and Water Management Division of MDEQ has the primary responsibility to ensure dam safety within the state. Following the September, 1986 flood in central Lower Michigan (see the description in the Significant Riverine Floods section), the current Dam Safety Act was passed to ensure that dams are built and maintained with necessary engineering and inspections for safety of the public and the environment. The Department of Environmental Quality is required to review applications involving construction, reconstruction, enlargement, alteration, abandonment and removal for dams that impound more than five acres of water and have a height of six feet or more.

Refer to the Dam Failures section for more information on this regulatory authority and hazard.

Manufactured Housing Commission Act, 1987 PA 96, as amended – The Michigan Manufactured Housing Commission Act and its implementing Administrative Rules provide regulation on the placement of manufactured homes, and establish construction criteria. Manufactured homes are prohibited from being placed within a floodway, as determined by the Department of Environmental Quality. In addition, manufactured homes sited within a floodplain must install an approved anchoring system to prevent the home from being moved from the site by floodwaters (or high winds), and be elevated above the 100 year flood elevation.

Local River Management Act, 1964 PA 253 – Enacted in 1964, the Local River Management Act provides for the coordination of planning between local units of government in order to carry out a coordinated water management program. Implementation of the water management program occurs through the establishment of watershed councils. These councils conduct studies on watershed problems, water quality, and the types of land uses occurring within the watershed. Watershed councils have the authority to develop River Management Districts for the purpose of acquisition, construction, operation, and financing water storage and other river control facilities necessary for river management. The provision to allow the acquisition of land adjacent to the river, for the purpose of management, aids in regulating the development of land prone to flooding.

State Flood Hazard Mitigation Plan

Michigan's governors have long recognized the need for flood mitigation activities. Executive orders and directives have been issued to create a State Flood Hazard Mitigation Plan. This responsibility has been shared by the Michigan Department of Environmental Quality, the Michigan State Police, and other governmental departments, in coordination

with the MHMCC (now the MCCERCC). Thus, those parts of the Michigan Hazard Mitigation Plan that deal with flooding have also served the function of providing the most recently updated detail for the State Flood Hazard Mitigation Plan, which (starting in 1977) mandated (1) the consideration of flood risks in the construction of buildings and roads, (2) the identification and mitigation of flooding at such facilities, where practical and economically feasible, (3) the attachment of appropriate restrictions upon flood prone lands that may be sold or given to non-state entities, and (4) the inclusion of flood hazard considerations by all state agencies involved in land use planning activities. Details regarding flood regulations, land use development efforts, coordination, and educational activities appear in this plan, including its list of hazard mitigation strategies.

Floodplain Service Program

The need to identify a flood hazard area before construction is essential to the goal of flood mitigation. The MDEQ regularly provides floodplain information to public and private interests as part of its Floodplain Service Program under the Water Resources Division. The goal of the program is to provide 100-year floodplain information to interested parties so that informed purchase or development decisions can be made. In addition to providing floodplain information, the MDEQ will provide information on land and water "interface" permit requirements and on building requirements relating to construction in flood hazard areas.

National Flood Insurance Program

For many years, the strategy for reducing flood damages followed a structural approach of building dams and levees and making channel modifications. However, this approach did not slow the rising cost of flood damage, and did not provide an affordable opportunity for individuals to purchase insurance to protect themselves from flood damage. It became apparent that a different approach was needed.

The National Flood Insurance Program (NFIP) was instituted in 1968 to make flood insurance available in communities that have agreed to regulate future floodplain development. As a participant in the NFIP, a community must adopt regulations that: 1) require any new residential construction within the 100-year floodplain to have the lowest floor, including the basement, elevated above the 100-year flood elevation; 2) require non-residential structures to be elevated or dry floodproofed (the floodproofing must be certified by a registered professional engineer or architect); and 3) require anchoring of manufactured homes in floodprone areas. The community must also maintain a record of all lowest floor elevations or the elevations to which buildings in flood hazard areas have been floodproofed. In return for adopting floodplain management regulations, the federal government makes flood insurance available to the citizens of the community. In 1973, the NFIP was amended to mandate the purchase of flood insurance, as a condition of any loan that is federally regulated, supervised or insured, for construction activities within the 100-year floodplain.

As of December 2010, there were 25,555 active flood insurance policies in Michigan. Officials from FEMA and the MDEQ estimate that only 15% of all flood-prone structures in Michigan eligible to purchase flood insurance actually have flood insurance. Furthermore, since only about 49% of the communities in Michigan participate in the NFIP, there are thousands of structures that are floodprone, but are not eligible to purchase flood insurance. (There were 867 participating communities as of December 22, 2010, and another 108 communities that were mapped but not participating—probably since the mapping was recently completed under FEMA's Map Modernization program.)

The following table provides listings of the 10 counties in Michigan which have the highest number of flood insurance policies in effect. The list is one indicator of the areas in Michigan that have the greatest potential for flood damage:

Top 10 Michigan Counties – Number of Flood Insurance Policies

County	Number of Policies
Wayne	3,975
Macomb	3,404
Monroe	2,452
St. Clair	2,085
Saginaw	1,828
Bay	1,368
Oakland	1,318
Ingham	957
Kent	721
Washtenaw	689

As of 12/31/2010; Source: Michigan Department of Environmental Quality

The top counties include the most urbanized areas of the state. The top counties are also located along the eastern shoreline of Michigan, along Lake Huron, Lake Erie, Lake St. Clair, and/or a connecting waterway such as the Detroit River or the St. Clair River.

The following table presents a slightly different ranking, in terms of the total amount of coverage, per county:

Top 10 Michigan Counties – Flood Insurance Coverage

County	Coverage (Thousand of Dollars)
Macomb	618,133
Wayne	586,507
Monroe	375,047
St. Clair	354,144
Oakland	286,764
Saginaw	201,381
Bay	189,667
Ingham	165,476
Kent	141,864
Washtenaw	129,390

As of 12/17/2010; Source: Michigan Department of Environmental Quality

Since 1978, about $45.1 million in claims have been paid due to flooding in Michigan. It should be remembered that officially claimed flood losses are only a small percentage of the total losses that are occurring from flood events. The flood insurance losses provide a good indication of where flooding problems currently exist, but they do not provide a good estimate of the total losses that are actually occurring. The following table lists the top ten Michigan counties in terms of highest amounts of flood insurance claims paid.

Top 10 Michigan Counties – Flood Insurance Claims Paid

County	Claims Paid (thousands of dollars)
Monroe	5,699
Wayne	4,094
Macomb	3,678
Kent	3,372
Bay	3,122
St. Clair	2,959
Berrien	2,654
Oakland	2,645
Saginaw	2,272
Ottawa	2,146

As of 12/31/2010; Source: Michigan Department of Environmental Quality

Since the Great Lakes experienced record high lake levels in 1985-86, and again in 1997-98, it is not surprising that seven of the ten communities showing the highest amount of flood insurance payouts occurred on the Great Lakes and connecting waterways. It should also be noted that the major riverine flood events that have occurred since 1978 have largely occurred in the inland and more rural areas of the state, which typically have lower flood damage potential.

The following tables present ranked lists of NFIP-participating communities, according to flood insurance coverage amounts, number of policies, and total claim amounts.

Top 10 Michigan Communities – Flood Insurance Coverage

Community	Coverage (Thousand of Dollars)
Harrison Township	243,621
Clay Township	190,730
St. Clair Shores, City of	177,661
Dearborn Heights, City of	154,184
Ann Arbor, City of	89,199
Gibraltar, City of	77,473
Lansing, City of	65,997
Chesterfield Township	64,277
Hamburg Township	50,400
Monroe Charter Township	49,957

As of 1/2011; Source: Michigan Department of Environmental Quality

Top 10 Michigan Communities – Number of Flood Insurance Policies

Community	Active Policies
Dearborn Heights, City of	1,343
Harrison Township	1,264
Clay Township	1,108
St. Clair Shores, City of	1,009
Frenchtown Charter Township	625
Gibraltar, City of	465
Lansing, City of	457
Bangor Township	438
Luna Pier, City of	352
Monroe Charter Township	315

As of 1/2011; Source: Michigan Department of Environmental Quality

Top 10 Michigan Communities – Flood Insurance Claims Paid

Community	Claims Paid (thousands of dollars)
Grand Rapids, City of	1,866
Midland, City of	1,823
Gibraltar, City of	1,807
Farmington Hills, City of	1,688
Luna Pier, City of	1,117
La Salle Township	1,109
Frenchtown Charter Township	1,097
Clay Township	1,080
Kalamazoo, City of	870
Castleton Township	863

As of 1/2011; Source: Michigan Department of Environmental Quality

The "Community Rating System" allows participating communities to earn discounts for their residents' flood insurance premiums. The following communities (as of October, 2010) are all CRS participants that have earned discounts of between 5% and 25% on the policy premiums for their NFIP-insured properties:

CRS Class 9 (5% discounts earned on NFIP policy premiums): Fraser Township, Park Township, Plainfield Township
CRS Class 8 (10% discounts earned): Bedford Township, Brooks Township, Commerce Township, Gibraltar City, Hamburg Township, Luna Pier City, Portage City, Richfield Township, Saginaw Township, Saugatuck City, Shelby Township, Taylor City, Taymouth Township, Zilwaukee City
CRS Class 7 (15% discounts earned): Dearborn Heights City, Novi City, Sterling Heights City
CRS Class 6 (20% discounts earned): Vassar City
CRS Class 5 (25% discounts earned): Midland City

Flood Management and Mitigation Education

The Water Resources Division of MDEQ has developed several guidance documents aimed at local officials involved in floodplain management and flood mitigation. These guidebooks are used as textbooks in training workshops and as a reference for day-to-day activities.

The Emergency Management and Homeland Security Division, Department of State Police, has developed a local hazard mitigation planning handbook for local officials. This guidance document provides an overview of a planning process that communities can follow to help reduce their vulnerability to a wide array of natural, technological and human-made hazards – including riverine flooding.

The Water Resources Division and the Emergency Management and Homeland Security Division periodically conduct floodplain management and flood hazard mitigation training courses and workshops for state and local officials. The Water Resources Division also conducts regular community assistance contacts and visits as part of its administrative duties under the National Flood Insurance Program. Such contacts/visits are a form of training aimed at improving a community's implementation of floodplain management practices. In addition, the Water Resources Division continuously conducts flood hazard workshops for lenders, realtors, building officials, engineers, citizens and any other interested parties.

Road Infrastructure Flood Mitigation Committee

Following the September, 1986 floods, the Michigan Department of Transportation (MDOT) formed a flood mitigation committee to determine ways to lessen damage to road infrastructure caused by riverine flooding. The committee consisted of representatives from the County Road Association of Michigan, the Federal Highway Administration, the MDEQ, and MDOT. One of the primary purposes of the committee was to identify reasons for failed stream crossings and damaged roads during a flood event, and make recommendations for achieving more flood-resistant stream crossings. The committee published its findings and recommendations in a report that is used today as a reference guide for officials involved in road infrastructure design and maintenance.

As a result of one of the committee's recommendations, the MDEQ regularly sponsors workshops and seminars on stream crossing design and erosion control practices. These workshops are geared toward design engineers at the state, county and local levels, in addition to private consultants and county drain commissioners.

1980s Voluntary Community-Initiated Acquisition and Relocation Projects

With the understanding that acquisition and relocation is one of the best ways to guarantee that homes and businesses will not continue to be repeatedly damaged by cyclical flooding, in the 1980s the cities of Owosso and Midland initiated voluntary acquisition and relocation programs using various community and privately-generated funds.

The **city of Owosso, Shiawassee County,** used Small Cities Block Grants and private investment to relocate 40 homes out of the floodplain, revitalize downtown development, and develop a park along the Shiawassee River.

The **city of Midland, Midland County,** rejected U.S. Army Corps of Engineer's proposals for dikes and channel improvements as too expensive and visually unfavorable. Instead, the City used Dow Foundation Grants and matching general revenue funds to purchase floodprone structures and return the property back to its natural state. The ongoing

purchase of properties has been entirely voluntary. Over 120 structures were purchased and removed from the floodplain.

Flood Mitigation Assistance Program (see also the other state-administered federal grants listed next)
With the passage of the National Flood Insurance Reform Act of 1994, Congress authorized the establishment of a federal grant program to provide financial assistance to states and local communities for flood mitigation planning and activities. The Federal Emergency Management Agency (FEMA) has designated this the Flood Mitigation Assistance Program (FMAP). The FMAP funds can be used to fund activities that reduce the risk of flood damage to structures insurable under the National Flood Insurance Program. The FMAP is state-administered (Emergency Management and Homeland Security Division) and cost-shared on a 75% federal, 25% local basis.

Three types of FMAP grants are available: 1) **planning grants** to assist local communities in developing flood mitigation plans; 2) **project grants** to fund eligible flood mitigation projects, with emphasis on repetitively or substantially-damaged structures insured under the NFIP; and 3) **technical assistance grants** to assist the State in providing technical assistance to applicants in applying for the program or implementing approved projects.

Repetitive Flood Claims Program
The Repetitive Flood Claims Program (RFCP) was created pursuant to Section 1323 of the National Flood Insurance Act of 1968, as amended by the Bunning-Bereuter-Blumenauer Flood Insurance Reform Act of 2004, with the goal of reducing flood damages to individual properties for which one or more claim payments for losses have been made under flood insurance coverage and that will result in the greatest savings to the National Flood Insurance Fund in the shortest period of time. RFCP funds may only mitigate structures that are located within a community that cannot meet the cost share or management capacity requirements of the FMAP. Grants under the RFCP are funded at 100% federal share. The RFCP is an annually appropriated, nationally competitive grant program. Eligible RFCP project activities include: 1) voluntary acquisition or elevation of qualifying structures, 2) dry floodproofing of qualifying non-residential structures, and 3) minor localized flood risk reduction projects that protect qualifying structures.

Severe Repetitive Loss Program
Similar to RFCP (listed above) but eligible properties are selected only from a special list noted as having suffered severe repetitive losses, and at up to a 90%/10% federal/local match share.

State and Federally-Assisted Relocation of Floodprone Properties
The State of Michigan has been very pro-active in its initiation and participation in the acquisition and relocation of floodprone properties, in both pre and post-disaster situations, using federal Hazard Mitigation Grant Program (HMGP) and Flood Mitigation Assistance Program funds. For extensive lists of these projects, and related information, please refer to Attachment C (Hazard Mitigation Funding Sources and Projects) in the Michigan Hazard Mitigation Plan.

Other State and Federally-Assisted Flood Hazard Mitigation Projects
The State of Michigan has used a variety of federal funding sources to assist in the implementation of flood mitigation projects. Those funding sources have included (1) the Hazard Mitigation Grant Program (HMGP), (2) the Flood Mitigation Assistance Program (FMAP), (3) the Pre-Disaster Mitigation Program (PDMP), (4) the Public Assistance Grant Program (PAGP), (5) the Presidentially Declared Disaster Assistance to Individuals and Households program, (6) Section 1362 of the National Flood Insurance Program (no longer in existence), (7) Community Development Block Grants (CDBG), and (8) Farmers Home Administration (FmHA) loans. State and local funds have been used to match the federal sources of funding. Please refer to Attachment C in the Michigan Hazard Mitigation Plan (Hazard Mitigation Funding Sources and Projects) for more information.

Flood Guidance for Local Hazard Mitigation Planning
Riverine flooding is a hazard that has been modeled for many decades now, and has some of the clearest methods of detailed analysis. Many guidance documents and publications are available to use in local assessments of this hazard, and local assessments are very important because of the much more detailed knowledge and more relevant authorities possessed at the local level. Much flooding affects individual locations that do not show up well in a statewide analysis.

Communities that are members of the NFIP probably have floodplain maps (called Flood Insurance Rate Maps, or FIRMs) that show where the floodplain areas are in the community and provide Base Flood Elevation (BFE) measurements. These calculations are based on surveying the topographical, hydrological, pedological, and land cover characteristics of the area's watershed. The result is a statistical model—a “100-year” floodplain area has a 1% chance of flooding in a given year, and the BFE is the water depth associated with an event of that probability. Some areas may flood less frequently, such as a 500-year floodplain which has a 1-in-500 chance of flooding in a given year. The names "100-year" and "500-year" can be very misleading. A "100-year" level flood may occur several times in a century, just as it is possible to flip a coin and get tails many times in a row. For detailed analysis of flooding, the basic principle of risk is that there is a 1% chance per year of flooding that is at the BFE level. For example, if BFE is 365' and the elevation of a structure's first floor is 363' above sea level, then the result would be floodwaters that are two feet over the ground floor of that structure. Lesser flooding is likely to occur with even greater frequency—if two feet of floodwaters hit that structure with 1% probability, the likelihood of getting just a few inches of floodwaters is even greater in a given year. Conversely, the likelihood of flooding that has three or four foot depths is far less than a 1% annual chance. FEMA models for flooding divide these events into different degrees of severity, based on their likelihood of annual occurrence. A few inches of water may be a "10-year" event in one area, but a "100-year" event somewhere else. Within the same floodplain area, a structure's elevation (and whether it has a vulnerable basement) may make all the difference between suffering severe damages, and experiencing no damages. Ideally, flood risk information can be combined with structural information (such as might be available through a building department or assessor's office) and a Geographic Information System (GIS) could make the analysis of such information easier.

It must also be noted that for some communities, these flood studies have become rather old and have not yet been verified or updated under the current Map Modernization program. Therefore, those who refer to these maps for hazard mitigation planning purposes are advised to review the original study’s data, model assumptions, and conclusions, to make sure that they are still representative of current conditions. Official floodplain maps that have been digitized are included in general form (smaller scale / less detail) at the end of this section.

Once risk categories have been established for vulnerable structures, the amount of damage from flood events can be estimated using FEMA techniques. The basic technique is to find the replacement value of the structure, and to estimate damages by equating different flood depths with appropriate percentages of that replacement value. The following table estimates damages to structures, in terms of the percentage of a building's replacement value, for different flood depths and structure types. (This table was adapted from Flood Insurance Administration guidance, based on historical averages from observed flood damages.)

FLOOD DAMAGE ESTIMATION TABLE
(Numbers given are damages as a percentage of the structure's replacement value)

	Type of structure					
Flood depths (depth of flooding in feet)	1 story, no basement	2 story, no basement	Split-level, no basement	1 or 2 story with basement	Split level with basement	Mobile home
Under ½ foot, in basement only	0	0	0	4	3	0
About 1 foot, in basement only	0	0	0	8	5	0
2+ feet in basement, <½' surface	9	5	3	11	6	8
About 1 foot flooding at surface	14	9	9	15	16	44
About 2' flooding on ground floor	22	13	13	20	19	63
About 3' flooding	27	18	25	23	22	73
About 4' flooding	29	20	27	28	27	78
About 5' flooding	30	22	28	33	32	80
About 6' flooding	40	24	33	38	35	81
About 7' flooding	43	26	34	44	36	82

NOTE: Since replacement value may exceed the current market value of a structure, damages greater than 50% of replacement value can be considered a total loss of the structure, unless special historic or service functions require that additional expenses be undertaken to repair and preserve it.

In addition, damages to the contents of structures can be estimated, by assuming that their value is 30% of the replacement value of the home, and then assuming that damages to those contents will be 1.5 times the percentages listed in the table above. This simple formula should be adequate for residential losses. (The structural and contents

formulas combine as follows: T = pR+.3R(1.5p) = pR+.45pR = 1.45pR.) Loss of contents in commercial facilities can be assessed more accurately by business owners or organizations participating in the development of a local plan. Other damages and costs could be those involving public facilities and infrastructure, road closures, diverted traffic, loss of rental income, and so on.

NOTE: The replacement value of a residential structure can be estimated, where information is not readily available. For example, construction costs for residential structures have been estimated to range from $101 to $116 per square foot (as found in the 2010 Residential Building Replacement Values of the International Code Council). In such a case, the typical price of $101 per square foot might be used unless you know that your area's costs are substantially higher or lower than average. This price can then be multiplied by the approximate square footage of residential use. For example, a 1000 s.f. house would have an estimated replacement cost of $101,000.

Hazard Mitigation Strategies for Riverine, Shoreline, and Urban Flooding

- Flood plain (and coastal zone) management – planning acceptable uses for areas prone to flooding (through comprehensive planning, code enforcement, zoning, open space requirements, subdivision regulations, land use and capital improvements planning) and involving drain commissioners, hydrologic studies, etc. in these analyses and decisions.
- Acceptable land use densities, coverage and planning for particular soil types and topography (decreasing amount of impermeable ground coverage in upland and drainage areas, zoning and open space requirements suited to the capacity of soils and drainage systems to absorb rainwater runoff, appropriate land use and capital improvements planning) and involving drain commissioners, hydrologic studies, etc. in these analyses and decisions.
- Dry floodproofing of structures within known flood areas (strengthening walls, sealing openings, use of waterproof compounds or plastic sheeting on walls).
- Wet floodproofing of structures (controlled flooding of structures to balance water forces and discourage structural collapse during floods).
- Elevation of flood-prone structures above the 100-year flood level.
- “Floating” architectural designs for structures in flood-prone areas
- Construction of elevated or alternative roads that are unaffected by flooding, or making roads more flood-resistant through better drainage and/or stabilization/armoring of vulnerable shoulders and embankments.
- Government acquisition, relocation, or condemnation of structures within floodplain or floodway areas.
- Employing techniques of erosion control within the watershed area (proper bank stabilization, techniques such as planting of vegetation on slopes, creation of terraces on hillsides, use of riprap boulders and geotextile fabric, etc.).
- Protection (or restoration) of wetlands and natural water retention areas.
- Obtaining insurance. (Requires community participation in the NFIP.)
- Joining the National Flood Insurance Program (NFIP). **VERY IMPORTANT!**
- Participation in the Community Rating System (CRS).
- Structural projects to channel water away from people and property (dikes, levees, floodwalls) or to increase drainage or absorption capacities (spillways, water detention and retention basins, relief drains, drain widening/dredging or rerouting, debris detention basins, logjam and debris removal, extra culverts, bridge modification, dike setbacks, flood gates and pumps, wetlands protection and restoration).
- Higher engineering standards for drain and sewer capacity, or the expansion of infrastructure to higher capacity.
- Drainage easements (allowing the planned and regulated public use of privately owned land for temporary water retention and drainage).
- Installing (or re-routing or increasing the capacity of) storm drainage systems, including the separation of storm and sanitary sewage systems.
- Farmland and open space preservation.
- Elevating mechanical and utility devices above expected flood levels.
- Flood warning systems and the monitoring of water levels with stream gauges and trained monitors.
- Increased coverage and use of NOAA Weather Radio.
- Anchoring of manufactured homes to a permanent foundation in flood areas, but preferably these structures would be readily movable if necessary or else permanently relocated outside of flood-prone areas and erosion areas.
- Control and securing of debris, yard items, or stored objects (including oil, gasoline, and propane tanks, and paint and chemical barrels) in floodplains that may be swept away, damaged, or pose a hazard when flooding occurs.

- Back-up generators for pumping and lift stations in sanitary sewer systems, and other measures (alarms, meters, remote controls, switchgear upgrades) to ensure that drainage infrastructure is not impeded.
- Detection and prevention/discouragement of illegal discharges into storm-water sewer systems, from home footing drains, downspouts and sump pumps.
- Employing techniques of erosion control in the area (bank stabilization, planting of vegetation on slopes, creation of terraces on hillsides).
- Increasing the function and capacity of sewage lift stations and treatment plants (installation, expansion, and maintenance), including possible separation of combined storm/sanitary sewer systems, if appropriate.
- Purchase or transfer of development rights – to discourage development in floodplain areas.
- Stormwater management ordinances or amendments.
- Wetlands protection regulations and policies.
- Use of check valves, sump pumps and backflow preventers in homes and buildings.

Tie-in with Local Hazard Mitigation Planning

Because many means of implementing mitigation actions occur through local activities, this updated MHMP places additional emphasis on the coordination of State-level planning and initiatives with those taking place at the local level. This takes two forms:

1. The provision of guidance, encouragement, and incentives to local governments by the State, to promote local plan development (including a consideration of riverine and urban flooding), and
2. The consideration of information contained in local hazard mitigation plans when developing State plans and mitigation priorities.

Regarding the first type of State-local planning coordination, MSP guidance has included the "Local Hazard Mitigation Planning Workbook" (EMD-PUB 207), which is currently being updated for release by 2015. For the second type of State-local planning coordination, a section later in this plan summarizes hazard priority information as it has been reported in local hazard mitigation plans. Here, it will merely be noted that flood hazards were identified as some of the most significant hazards in local hazard mitigation plans for the following counties: Allegan, Baraga, Bay, Benzie, Berrien, Calhoun, Charlevoix, Clinton, Eaton, Emmet, Gogebic, Grand Traverse, Gratiot, Houghton, Ingham, Ionia, Kent, Leelanau, Macomb, Manistee, Marquette, Mecosta, Menominee, Midland, Montcalm, Oakland, Osceola, Ottawa, Saginaw, St. Clair, Shiawassee, St. Joseph, Tuscola, Van Buren, Wayne, and Wexford.

Flooding History for Michigan Counties – arranged by region – Jan. 1996 to Oct. 2013
(The Lower Peninsula regions are ordered by "tiers" from south to north, west to east)
Please refer to the Michigan Profile Map section for an explanation of regional divisions

COUNTY or area	Riverine Flooding Events	Days with Riverine Flooding	Tot. property damage	Tot. crop damage	Injuries	Deaths
Washtenaw	30	28	$13,050,000			
Wayne	59	48	$22,460,000			
.Livingston	17	17	$1,304,000			
Oakland	22	22	$2,706,000			1
Macomb	34	29	$101,680,000			
5 Co Metro region	**32.4 avg.**	**28.8 avg.**	**$141,200,000**			**1**
Berrien	20	17	$6,810,000	$100,000		
Cass	21	14	$6,560,000	$100,000		
St. Joseph	18	14	$6,560,000	$100,000		
Branch	14	11	$6,060,000	$100,000		
Hillsdale	20	14	$6,210,000	$100,000		
Lenawee	36	36	$6,710,000	$100,000		
Monroe	29	26	$9,790,000	$100,000		3
.Van Buren	24	19	$10,553,000	$350,000		
Kalamazoo	27	23	$23,920,000	$360,000		
Calhoun	27	23	$12,695,000	$435,000		
Jackson	25	22	$11,020,000	$405,000		
.Allegan	34	29	$21,050,000	$7,425,000	4	2
Barry	29	23	$13,170,000	$800,000		
Eaton	25	21	$11,945,000	$825,000		
Ingham	26	21	$17,420,000	$475,000		
.Ottawa	34	28	$54,225,000	$2,005,000	3	2
Kent	38	32	$10,530,000	$610,000		
Ionia	21	17	$14,220,000	$350,000		
Clinton	26	21	$12,395,000	$475,000		
Shiawassee	27	24	$7,231,000	$100,000		
Genesee	38	31	$13,810,000	$100,000		
Lapeer	28	25	$15,680,000	$1,100,000		
St. Clair	24	24	$9,480,000	$100,000		
.Muskegon	28	22	$12,855,000	$635,000		
Montcalm	24	19	$10,345,000	$475,000		
Gratiot	26	21	$10,345,000	$475,000		
Saginaw	48	42	$8,737,000	$1,100,000		
Tuscola	32	26	$14,030,000	$100,000		
Sanilac	21	17	$8,145,000	$100,000		
.Mecosta	27	22	$16,115,000	$445,000		
Isabella	27	22	$14,350,000	$475,000		
Midland	25	21	$8,730,000	$100,000		
Bay	24	20	$8,920,000	$125,000		1
Huron	23	19	$6,219,000	$100,000		
34 Co S Lower Pen	**26.9 avg.**	**22.5 avg.**	**$426,835,000**	**$20,745,000**	**7**	**8**

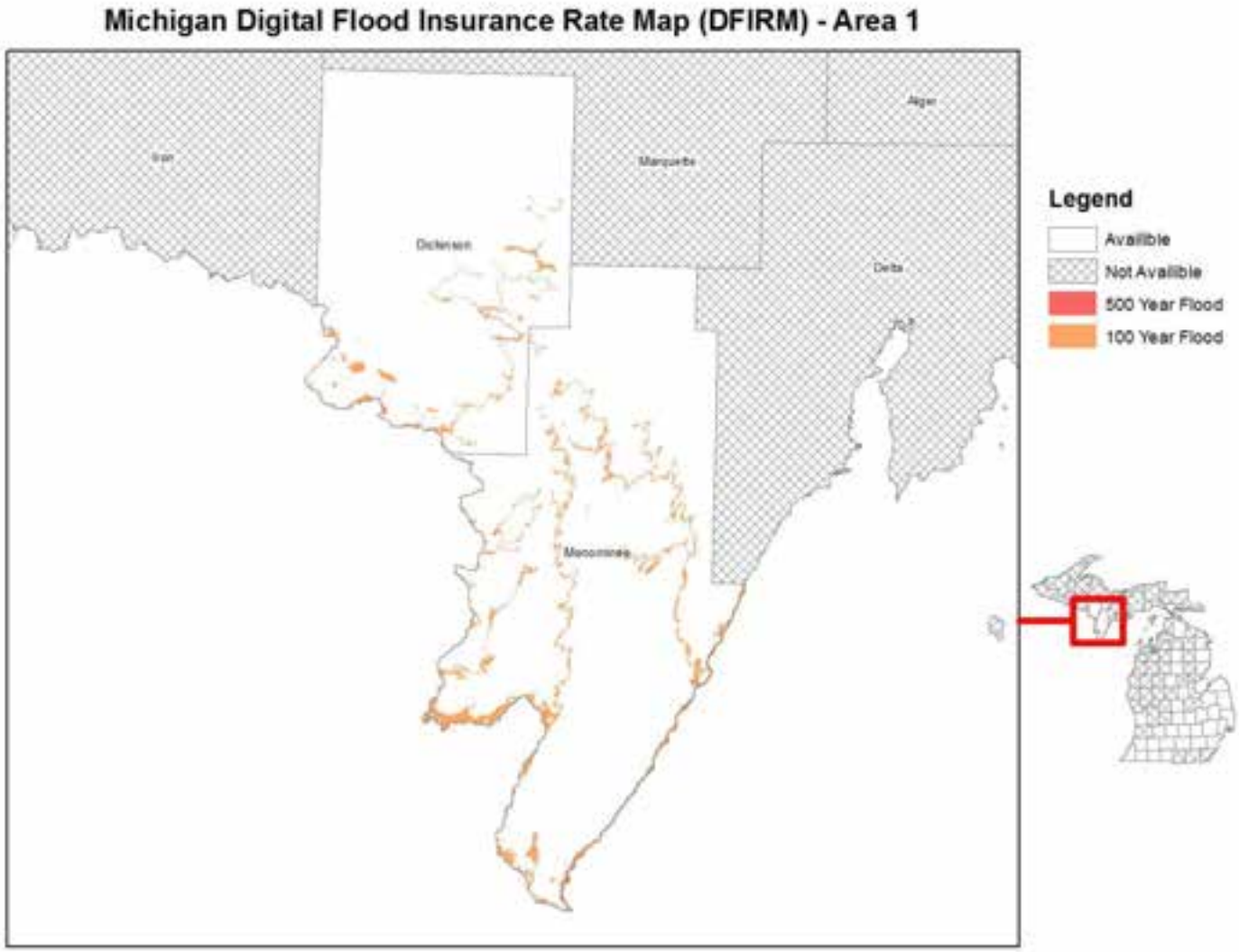
Continued on next page…

Part 2 of Michigan County Flood History Table

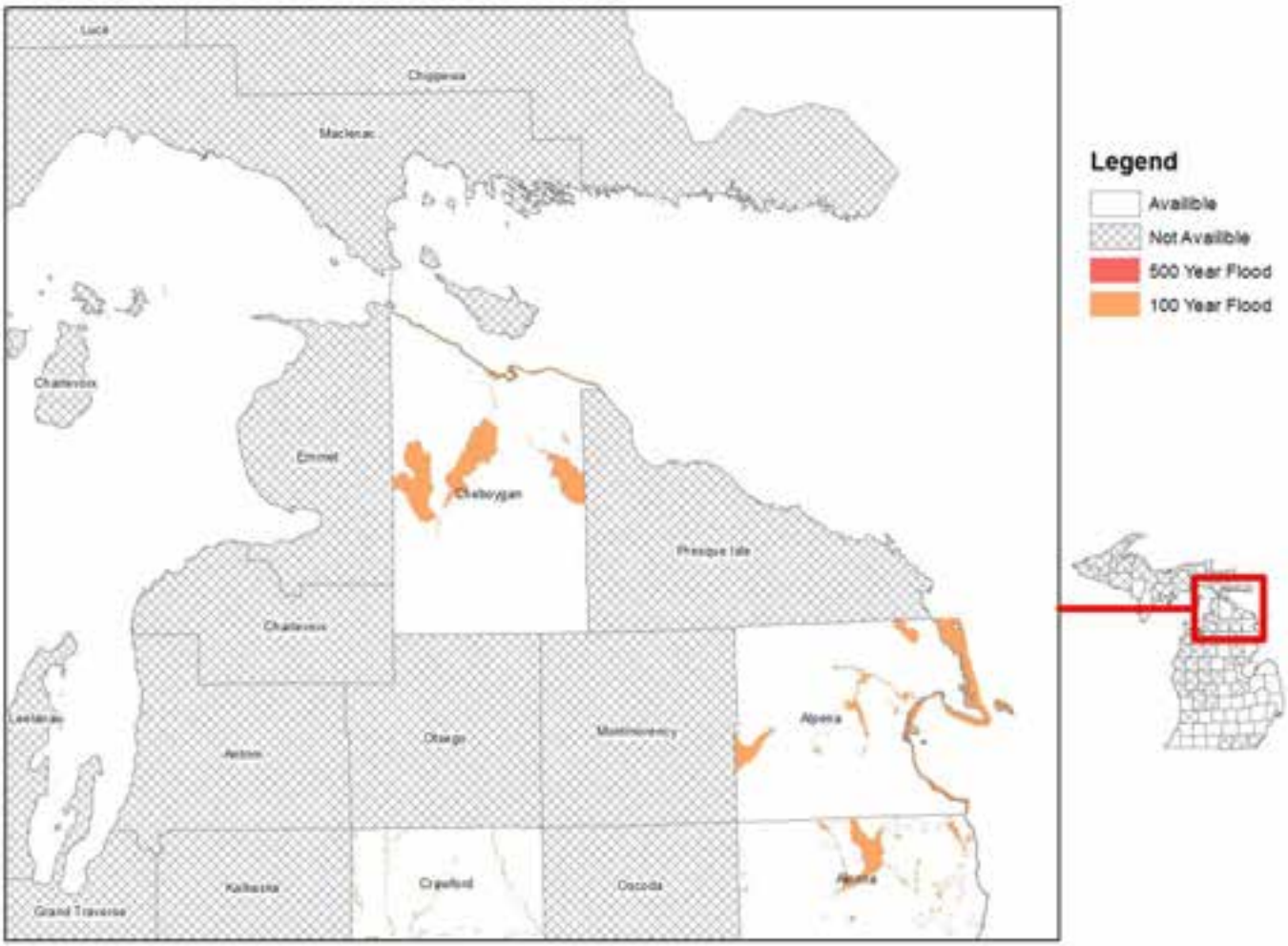
.Oceana	9	8	$4,660,000	$450,000		
Newaygo	10	8	$6,360,000	$350,000		
.Mason	13	11	$7,355,000	$850,000		
Lake	8	8	$6,190,000	$700,000		
Osceola	11	10	$5,250,000	$575,000		
Clare	8	8	$4,175,000	$275,000		
Gladwin	7	6	$103,000			
Arenac	13	13	$98,000			
.Manistee	8	7	$1,520,000			
Wexford	10	10	$872,000			
Missaukee	3	3	$160,000			
Roscommon	1	1	$4,000			
Ogemaw	3	3	$150,000			
Iosco	3	3	$3,000			
.Benzie	1	1				
Grand Traverse	6	6	$1,814,000			
Kalkaska	2	2	$20,000			
Crawford	1	1	$6,000			
Oscoda	3	3	$3,000			
Alcona	4	4	$110,000			
.Leelanau	2	2	$50,000			
Antrim	1	1				
Otsego	1	1	$3,000			
Montmorency	1	1				
Alpena	1	1				
.Charlevoix	1	1	$2,000			
Emmet	1	1	$18,000			
Cheboygan	3	3	$28,000			
Presque Isle						
29 Co N Lower Pn	**4.7 avg.**	**4.4 avg.**	**$38,954,000**	**$3,200,000**		
Gogebic	13	13	$19,011,000			
Iron	10	10	$645,000			
Ontonagon	12	12	$817,000			
Houghton	17	16	$2,900,000			
Keweenaw	7	7	$132,000			
Baraga	14	13	$2,044,000			
.Marquette	27	17	$14,725,000			
Dickinson	11	8	$31,000			
Menominee	5	5	$850,000			
Delta	22	16	$805,000			
Schoolcraft	3	3				
Alger	6	5				
.Luce	3	3				
Mackinac	5	4	$58,000			
Chippewa	6	6	$125,000			
15 Co Upp.Pen	**10.7 avg.**	**9.2 avg.**	**$42,143,000**			
MICHIGAN TOTAL	**925**	**338**	**$437,407,000**	**$20,645,000**	**7**	**9**

NOTE: Due to the double counting of multi-county events, state totals are less than the sum of the counties.

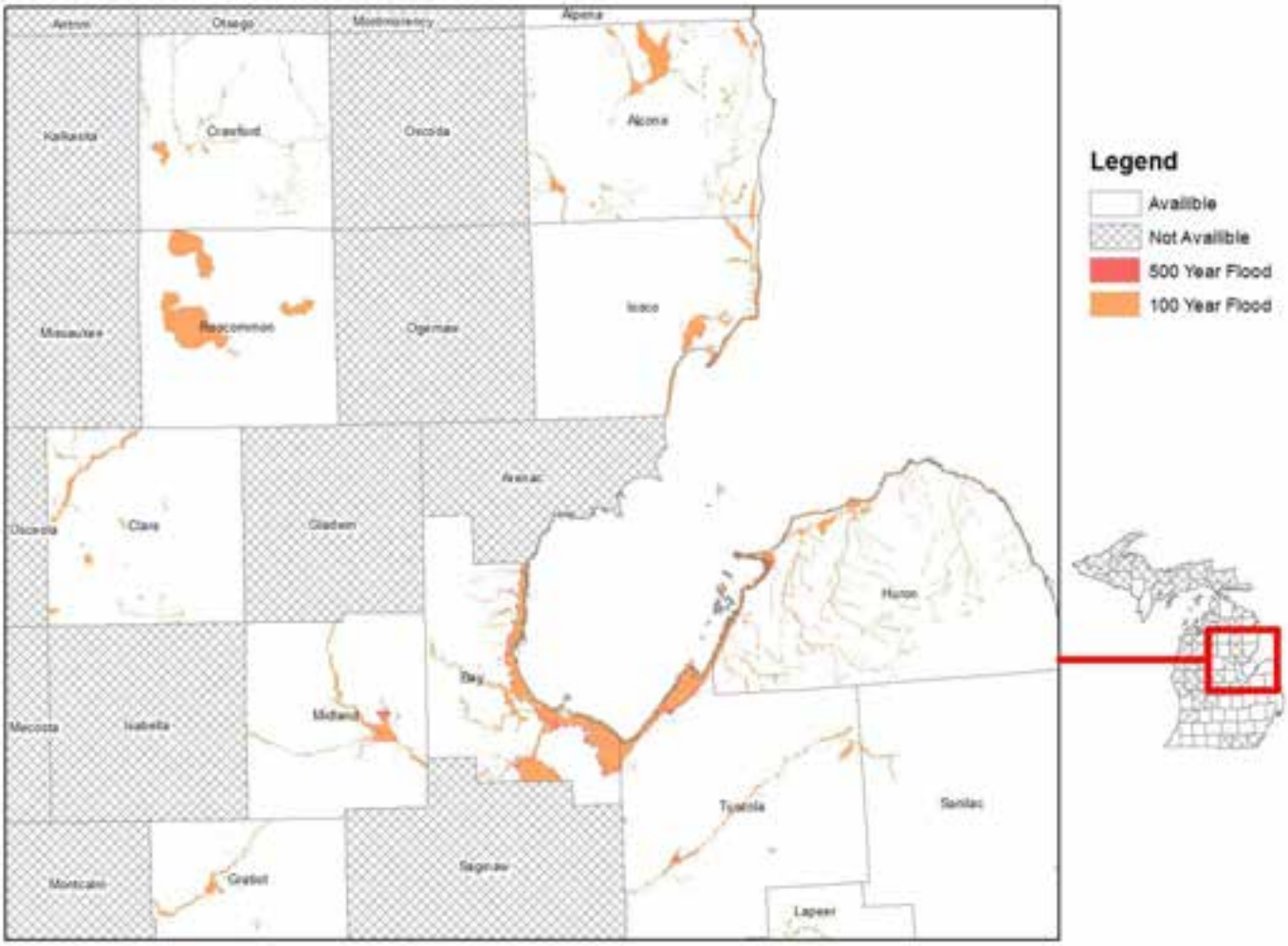
Michigan Digital Flood Insurance Rate Map (DFIRM) Availibility
Keweenaw
Keweenaw
Houghton
Ontonagon
Baraga
Gogebic
Marquette
Alger
Luce
Chippewa
Iron
Schoolcraft
Mackinac
Dickinson
Delta
Menominee
Charlevoix
Emmet
Cheboygan
Presque Isle
Charlevoix
Leelanau
Antrim
Otsego
Alpena
Montmorency
Leelanau
Grand Traverse
Kalkaska
Crawford
Oscoda
Alcona
Benzie
Manistee
Wexford
Roscommon
Ogemaw
Iosco
Missaukee
Arenac
Mason
Lake
Osceola
Clare
Gladwin
Huron
Bay
Oceana
Mecosta
Isabella
Midland
Newaygo
Tuscola
Sanilac
Montcalm
Gratiot
Saginaw
Muskegon
Lapeer
Genesee
Ottawa
Kent
Ionia
Clinton
Shiawassee
St. Clair
Oakland
Macomb
Allegan
Barry
Eaton
Ingham
Livingston
Van Buren
Kalamazoo
Calhoun
Jackson
Washtenaw
Wayne
Monroe
Berrien
Cass
St. Joseph
Branch
Hillsdale
Lenawee
Legend
Availible
Not Availible


Michigan Digital Flood Insurance Rate Map (DFIRM) - Area 1
Iron
Dickinson
Marquette
Alger
Delta
Menominee
Legend
Available
Not Available
500 Year Flood
100 Year Flood

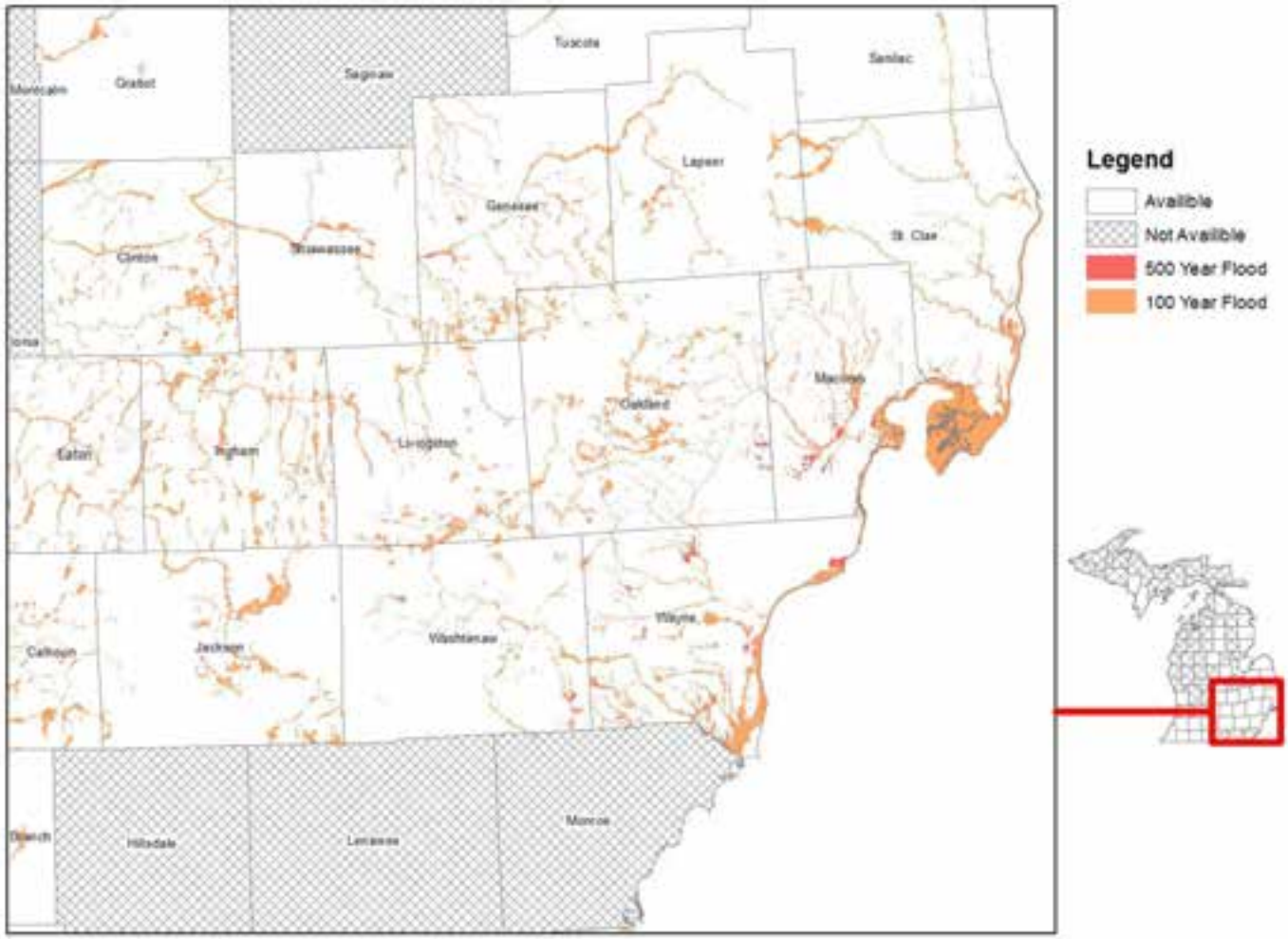
Michigan Digital Flood Insurance Rate Map (DFIRM) - Area 2



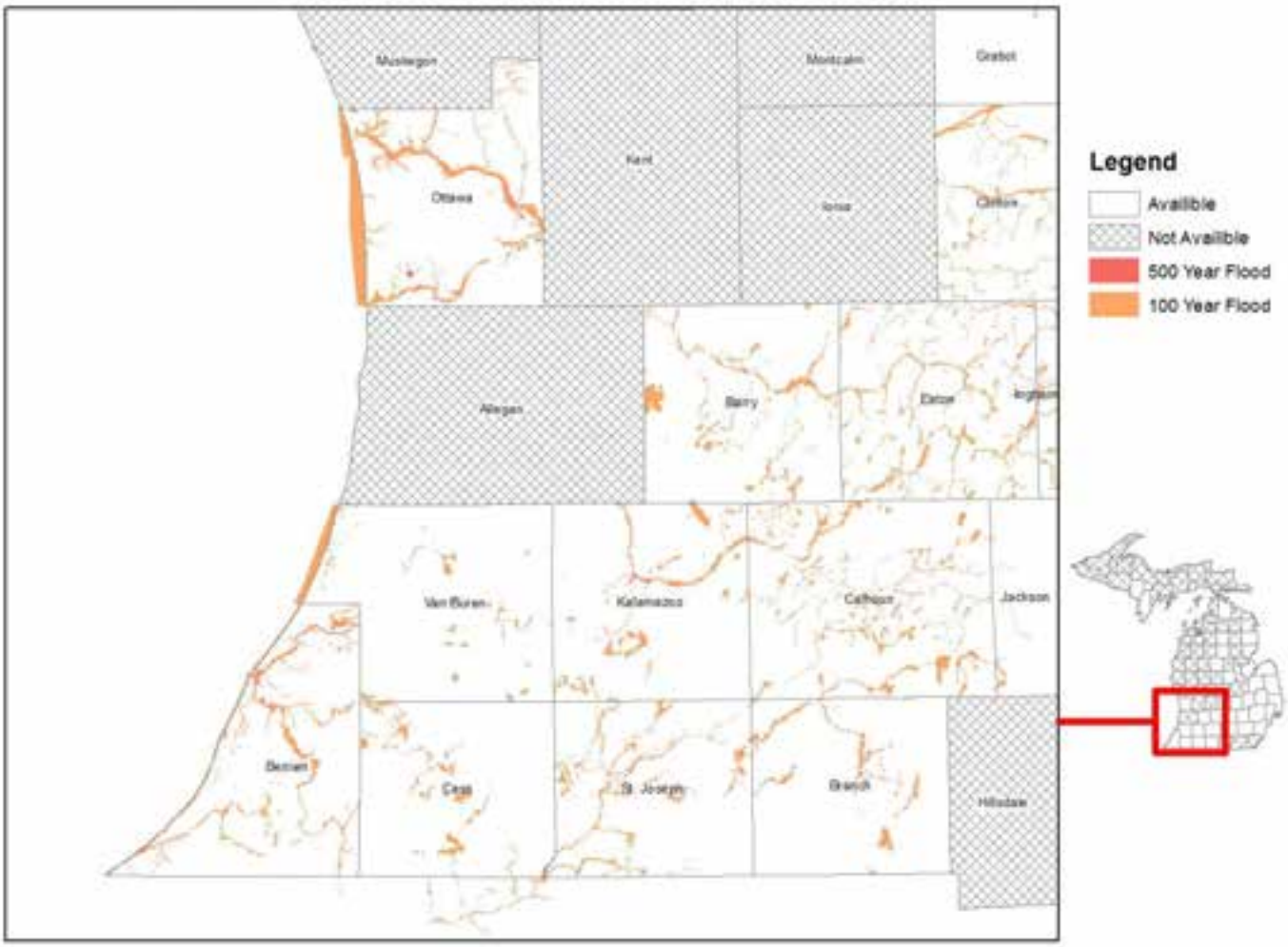
Michigan Digital Flood Insurance Rate Map (DFIRM) - Area 3



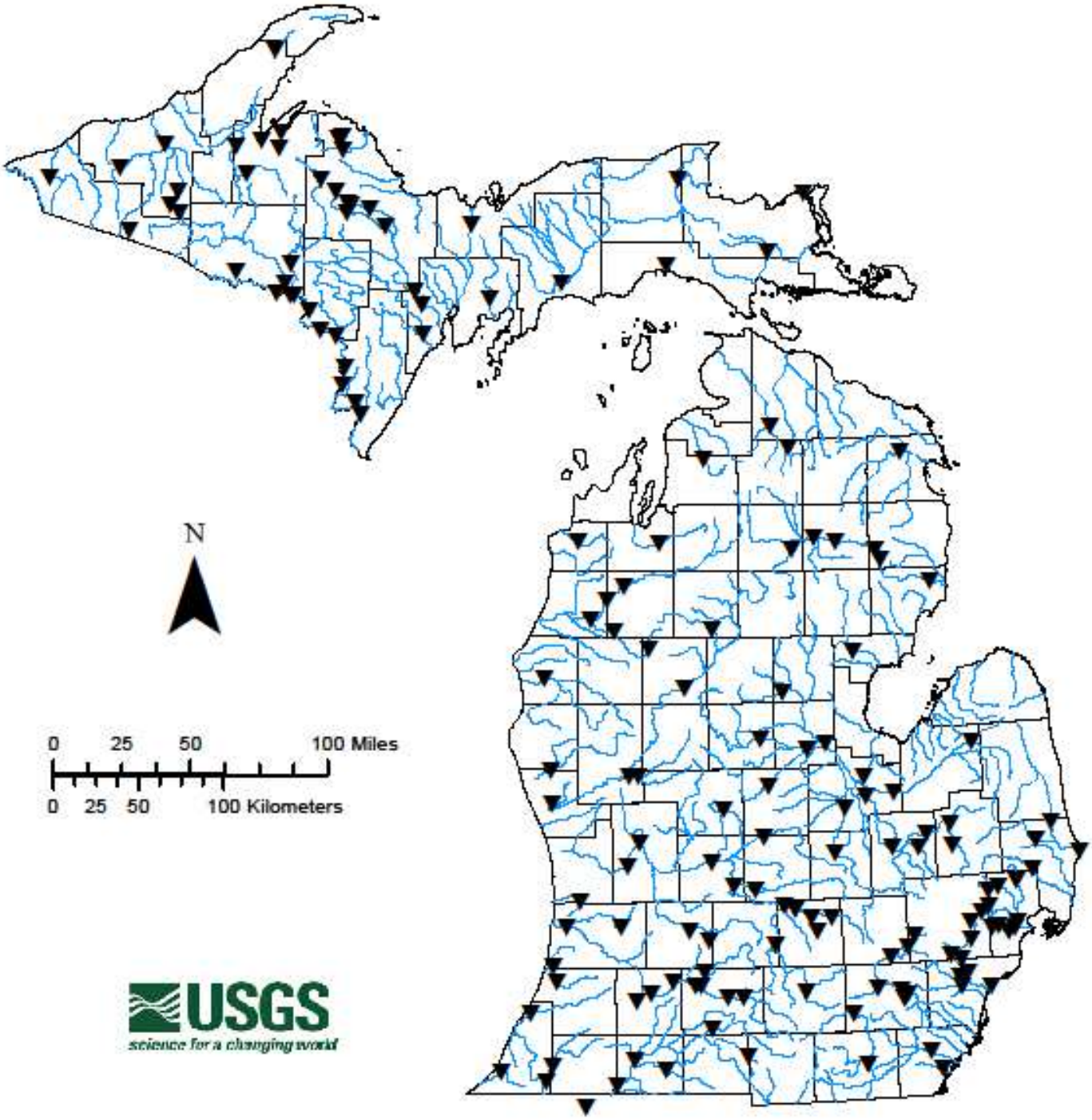
Michigan Digital Flood Insurance Rate Map (DFIRM) - Area 4



Michigan Digital Flood Insurance Rate Map (DFIRM) - Area 5



USGS Stream Gauge Locations in Michigan



Great Lakes Shoreline Hazards

High or low water levels that cause flooding or erosion, and other wave and current action that threatens life, health, and property in shoreline areas, including storm surges, rip currents, and the recession of shoreline areas.

Hazard Description

Michigan has over 3,200 miles of coastline (the longest freshwater coastline in the world), and about 4.7 million persons live in the state's 41 shoreline counties. Wind, waves, water levels, and human activities constantly affect the communities along the shores of the Great Lakes. Shoreline flooding and erosion are natural processes, occurring at high, average, and even low Great Lakes water levels. However, during periods of high water, flooding and erosion are more obvious, causing serious damage to homes and businesses, roads, water and wastewater treatment facilities, and other structures in coastal communities. Low lake levels can also pose a hazard, as cargo ships are more prone to running aground and the shorelines may also become more polluted from lake bottom debris. Long-term and seasonal variations in precipitation and evaporation rates primarily control the Great Lakes water levels and their fluctuations.

The Great Lakes occupy an area of 95,000 square miles and drain an amount of land twice that size. They hold nearly one-fifth of the world's fresh surface water. Because the land draining into the Great Lakes is so vast, changes in the amount of water running into the lakes from precipitation within the basin has an enormous effect on water levels. Following long periods of above-average yearly precipitation, there is an accompanying rise in water levels. This rise is not immediately evident because of the delay between the time precipitation falls within the drainage basin and the time that runoff waters enter the lakes. (The same holds true for below-average yearly precipitation. The reduced flow of runoff water eventually results in lower Great Lakes water levels.)

Hazard Analysis

Over one hundred years of record keeping have not indicated a simple, easily-predictable cycle of water levels on the Great Lakes. (However, geologic research has indicated quasi-periodic cycles of 33 years and 160 years for lake level fluctuations; e.g. Baedke and Thompson's article in the Journal of Great Lakes Research, v.26 p. 416-426, 2000.) The time between periods of high and low water levels can vary widely. Records indicate the maximum differences in levels have varied from nearly four feet on Lake Superior to over six and one-half feet on Lakes Michigan and Huron. Seasonal fluctuations caused by more water runoff can cause lake level fluctuations averaging about one foot on Lakes Superior, Michigan and Huron, and one and one-half feet on Lake Erie. The graphs at the end of this section show the average historical water levels of the Great Lakes up through 2009.

In addition to natural causes of water level fluctuation, there are four man-made factors that can also affect water levels to some degree: (1) diversion of water for power generation, municipal water supply, and navigation, (2) regulation of water levels via dams and other control structures, (3) dredging of connecting waterways for navigation purposes, and (4) covering land surfaces with impervious materials that cause storm runoff to be delivered to water bodies more quickly than the pre-development runoff rates. Although these man-made factors do impact water levels, natural factors such as precipitation, evaporation and winds have a far greater overall impact. The vast majority of shoreline flooding and erosion that occurs along the Great Lakes is caused by natural factors. However, it should be remembered that it is humans who place themselves in harm's way by building structures in dynamic coastal areas. If that did not occur, the natural processes of flooding and erosion would not be viewed as problems.

Generally, low-lying lands along the coastline are prone to shoreline flooding during both high and low lake water periods. The Michigan Department of Environmental Quality estimates that approximately 10% of Michigan's Great Lakes shoreline (30 counties encompassing greater than 45,000 acres) is floodprone.

The map at the end of this section indicates those townships that contain high-risk erosion areas as determined by the MDEQ under Part 323, Shorelands Protection and Management. A high-risk erosion area is defined by the MDEQ as an area where erosion studies have indicated that the erosion hazard line is receding at an average of one foot or more per year over a minimum 15-year period. The MDEQ has identified 121 township areas along the Great Lakes coast as containing one or more sections of high-risk erosion areas. Within those areas, any new permanent structure must comply with building setback regulations that require a minimum distance between the existing erosion hazard line and

the structure. (The MDEQ also designated 41 communities on Michigan's shoreline as flood risk areas, meaning that they have floodplain-like areas with at least a 1% annual chance of a designated flood level being exceeded.)

The intent of these and other applicable building restrictions is to minimize the extent and magnitude of shoreline flooding and serious erosion problems along the Great Lakes shoreline. Although shoreline flooding and erosion is inevitable, severe damage can be avoided if prudent shoreland management practices are followed and adequate emergency procedures are implemented. Coordination of federal, state and local shoreland management and emergency preparedness efforts is vital to keeping Michigan's shoreline areas as safe and undamaged as possible. The recession of the Great Lakes water levels is also inevitable, but there is not much, other than dredging, that can be done to combat the negative effects. That is why it is important for all those involved in water transportation to be prepared for all types of water fluctuations.

Much of Michigan's character is defined by the Great Lakes. The beaches provide numerous recreational opportunities and are considered prime real estate. Unfortunately, the inherent hazards of coastal areas are not always apparent. Development activities along the shoreline significantly alter the natural ebb and flow of coastal dynamics. Continuing and increasing development of coastal areas threatens to exacerbate the shoreline flooding and erosion problem. As more people and structures are put in harm's way, the problem of shoreline flooding and erosion will continue to grow in frequency and significance.

The MDEQ administers programs aimed at balancing the impact of shoreline flooding and erosion with the development pressures facing the Great Lakes shoreline by implementing non-structural approaches, such as construction setbacks and lowest floor elevation requirements. These types of approaches do not interfere with the natural processes of erosion and flooding, but instead take what is known about the coastal hazard and develop construction standards to prevent the premature collision between homes and nature.

The MDEQ has the responsibility of administering the permitting programs that implement the coastal construction standards. However, under Part 323, local governments have the authority to take over the permitting programs for high-risk erosion and flood risk areas. In the area of floodplain management, permitting responsibility is handled at the local level due to the overlap of regulations found in Part 323, the NFIP, and the building codes. However, few communities have shown an interest in adding the regulatory responsibility of the erosion program to their already busy building and zoning departments. As with many regulatory programs that address private property development rights, the potential for conflict in these areas is high. This is especially true in the realm of expensive shoreline real estate where a view of the water can outweigh the threat of future flood or erosion damage. Political pressure can also come into play in some situations. Compliance with these regulations has best been achieved through cooperation between the State and local governments. Public understanding and support of these programs can be increased by improved communication with property owners regarding the natural hazards associated with the Great Lakes shoreline. About 10 major periods of flooding/erosion have occurred on the Great Lakes since 1918—about every 8.3 years.

Shoreline erosion hazards typically involve the loss of property as sand or soil is removed by water action and carried away over time. Erosion effects that are experienced along rivers may be included in this category of hazard. Worst case scenarios typically involve occupied structures that, over the years, have had adjacent lands eroded away and now stand perilously close to waters or cliffs. The foundation of a structure, or underground utility pipes in the area, may become fully exposed and vulnerable to weather, extreme temperatures, water damage, or other sources of risk.

Another frequent situation in Michigan involves shoreline roadways whose banks erode and cause the road surface to crack, become unstable, or more prone to deposits of sand, snow, water and ice from nearby beaches and water bodies. The costs of delayed traffic and detours can be counted as harmful shoreline effects.

Storm Surges (Seiches)

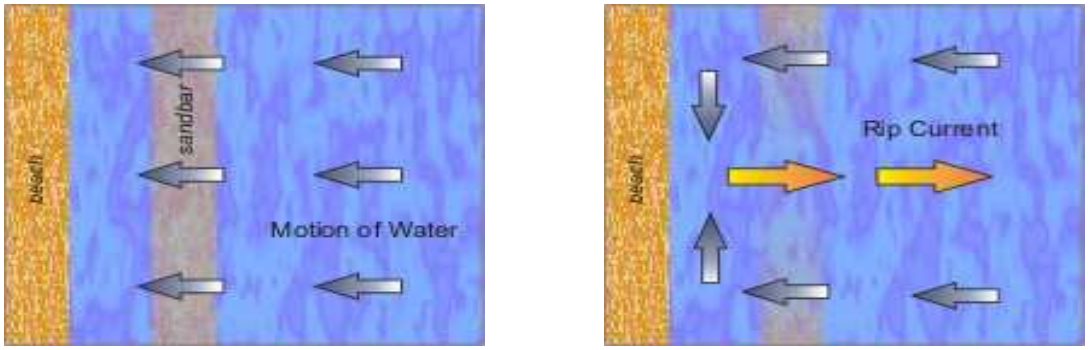
Weather-related events can also cause lake fluctuations that can last from several hours to several days. For example, windstorms combined with differences in barometric pressure can temporarily tilt the surface of a lake up at one end by as much as eight feet. This phenomenon is called a **storm surge** or **seiche** (typically pronounced as saysh) and can drive lake waters inland over large areas, cause weakening and erosion of shoreline areas, make water travel hazardous, and cause flood damages, deaths, and injuries to occur. The following list presents some of the most significant seiche events to have affected Michigan.

Rip Currents

A rip current is a strong flow of water returning seaward from the shore. When wind and waves push water towards the shore, the previous backwash is often pushed sideways. This water streams along the shoreline until it finds an exit back to the sea. The resulting rip current is usually narrow and located between sandbars, under piers or along jetties. The current is strongest at the surface, and can dampen incoming waves, leading to the illusion of a particularly calm area. Rip current speeds are typically 1-2 feet per second. However, speeds as high as 8 feet per second have been measured. Rip currents cause approximately 100 deaths annually in the United States, more than all other natural hazards except excessive heat. In the Great Lakes alone, the average over the last six years is 10 drownings per year caused by rip currents. About 80% of rescues by surf beach lifeguards are due to rip currents. A picture showing how rip currents are formed can be found below.

In recent years, rip current advisories have been announced by the National Weather Service, as a part of their weather warning information system. These warnings advise about dangerous swimming conditions, and that rip currents are more likely to exist near break walls, sandbars, jetties, and piers. Persons who are caught in a rip current should wade or swim sideways (parallel to the beach) so as to leave the rip current area before it pulls them too far away from shore. The most important action is to conserve one's strength so as to stay afloat (rather than expending one's strength in an over-desperate struggle to "fight the current"). Once out of the rip current's pull, head back to shore at a pace that is appropriate to one's strength. In some circumstances, a swimmer may have been observed by beach lifeguards while being pulled by the current, and in such a case, if waves and weather are not too severe to allow a rescue, a swimmer may simply need to stay afloat until the lifeguards can bring aid.

Rip Current Formation



According to the National Climatic Data Center, Michigan has experienced at least 29 deaths and 9 injuries caused by rip currents or other shoreline hazards since 1996. Out of 36 events, 17 took place in the Lake Michigan waters off of Berrien County (a total of 15 dead and 8 injured). Problem locations included the waters south of Bridgman down to Harbart, and a couple of incidents off of Silver Beach (in the City of St. Joseph). A two-page table that summarizes all shoreline hazard events and casualties appears within this section.

Another Great Lakes hazard is the potential effect of severe winds upon boating activities. Although some description of marine accidents can be found in the Transportation Accidents section, it must be noted here that severe winds tend to be felt more strongly on open waters (winds from an approaching storm front often strike in advance of the storm itself, by 5 minutes or even more). Waterspouts (which are like a tornado, but involve contact with water instead of land) are a common occurrence posing a great threat to marine traffic. Seventeen Michigan waterspouts have been noted by NCDC between 1993 and 2001, including one that caused $200,000 in damage to a boat house and storage building at Drummond Island on July 3, 1999. Many additional events have occurred since, which NCDC has classified according to the corresponding lake location rather than as part of Michigan itself. Waterspouts are less frequent on Lake Superior (8 events since 2001) than on Lakes Huron (23 events) or Michigan (51 events).

Shoreline flooding can sometimes be treated in a manner similar to riverine flooding, when there are specifically identified shoreline areas with significant flood risks that have been calculated and mapped (e.g. by the NFIP). In some cases, these areas may suffer unusually heavy damages due to the added effects of wave action and seiche activities on the Great Lakes.

Shoreline erosion hazards typically involve the loss of property as sand or soil is removed by water action and carried away over time. Erosion effects that are experienced along rivers may seem similar, but the potential for sudden damaging impacts tends to be greater on the shoreline areas. Worst case scenarios typically involve occupied structures or important streets and infrastructure that, over the years, have had adjacent lands eroded away and now stand perilously close to waters or cliffs. The foundation of a structure, or underground utility pipes in the area, may become fully exposed and vulnerable to weather, extreme temperatures, water damage, or other sources of risk.

Another frequent situation in Michigan involves shoreline roadways whose banks erode and cause the road surface to crack, become unstable, or more prone to deposits of sand, snow, water and ice from nearby beaches and water bodies. The costs of delayed traffic and detours can be counted in the analysis. Travel on shoreline highways can also be made treacherous by sand, mists, and snow blown in by wind gusts.

Impact on the Public

Great Lakes shoreline flooding is similar to inland (riverine) flooding in some ways (such as having a probabilistically definable flood risk area), but the shoreline tends to have a much greater risk of allowing strong wave action as part of a flood's impacts. Storm seiches can make the magnitude of shoreline flooding much greater than what is possible in most inland areas. In addition, patterns of Great Lakes shoreline erosion tend to be a larger issue than the erosion associated with Michigan's rivers, since the water effects are greater, and the topographic relief in Michigan's shoreline areas is sometimes considerable. For example, the erosion effects from a single severe thunderstorm have caused large sections of shoreline roadway to crumble and disappear into the crashing waters, involving a drop of dozens of feet on the southern coasts of Lake Michigan, and have encroached upon structures located nearby.

Impact on Public Confidence in State Governance

Great Lakes shoreline flooding and erosion impacts are probably similar to those of riverine flooding, except that shoreline impacts may seem to be less controllable than riparian impacts. Erosion severity is likely to be far greater along the shoreline, especially when involving substantial elevations in which the roads and homes are located along bluffs or cliffs and are thus clearly imperiled by any degradation in the solidity of the supporting land structure that is subjected to erosion and weakening. Thus, part of the public may be prone to question why structures were allowed to be built in an area at-risk from erosion effects, or whether some government-funded mitigation action may be undertaken to preserve the condition and value of such property, once it is recognized as being at-risk.

Impact on Responders

Compared to riverine flood events, the main additional risks posed by shoreline flooding and erosion hazards involve the generally greater topographic relief along certain shoreline areas, and the greater potential impact likely to be seen from a single event such as a storm or seiche that involves substantial wave action. The event may cause roadways and property to crumble and tumble dozens of feet into the waters of one of the Great Lakes. Thus, weakened shoreline roads may cause personnel, vehicles, or equipment to plummet down a steep incline, if erosion has been severe enough to cause such a collapse. Shoreline events may also require more extensive use of boats and marine equipment during response activities, with an associated increase in the variety of risks to responders.

Impact on the Environment

Great Lakes shoreline flooding and erosion does the greatest amount of harm to the built environment by destroying structures that are built too close to the shoreline. However, shoreline erosion can also affect the natural environment by altering the landscape, with the potential to permanently destroy wildlife habitat.

Significant Periods of Shoreline Flooding and Erosion

In most decades, high water levels on the Great Lakes have caused significant damage and impacts to Michigan coastal communities.

During 1972-73, high water levels caused flooding in over 30 counties, resulting in more than $50 million in public and private damage. Thousands of people were forced to evacuate their homes. Similar high water-level flooding occurred in the early 1950s and late 1960s, also resulting in millions of dollars worth of damage to shoreline communities.

Record-high lake levels in 1985-86 culminated in a Governor's disaster declaration for 17 shoreline counties. The USACE implemented its Advance Measures Program, and the State of Michigan implemented three unique shoreline flooding and erosion mitigation programs aimed at reducing future flood impacts on shoreline communities and homeowners. (See Programs and Initiatives section.)

The most recent high water period, in 1997-98 (although it should be noted that Lake St. Clair and Lake Erie have recently gone back up to above-average levels), resulted in the Great Lakes being at or near the record levels set in the mid-1980s. In response to the threat of severe shoreline flooding and erosion, the U.S. Army Corps of Engineers (USACE), at the request of the Governor, implemented its Advance Measures Program to assist Michigan shoreline communities in their flood and erosion mitigation efforts. (See Programs and Initiatives section for more details.) More than 20 Michigan jurisdictions have since taken advantage of this program.

Significant Periods of Great Lakes Recession

Just as damaging high water levels frequently occur in the Great Lakes, low water levels are also cyclical and can have severe economic impacts.

The low water levels in Lakes Michigan, Huron and Erie between 1998-2004 (Lake Erie has since recovered) were the fastest decline in water levels in the Great Lakes in nearly a century and a half. Between the summer of 1997 and the spring of 2003, the middle Great Lakes (Michigan, Huron, and Erie) each dropped by almost five feet.

One contributing factor to low lake levels is a lack of snow pack runoff from moisture that had originated outside of the Great Lakes basin, such as the Gulf of Mexico. (In some years with low lake levels, there may be good snow pack runoff, but it had all originated from lake-effect snow and thus didn't cause a net increase in lake water levels.) The Lake Superior basin, which is the headwaters for the Great Lakes, is an important factor in lake levels. In the past, low snow pack in the Lake Superior basin has disrupted the other lakes' seasonal replenishment cycle, driving water levels down.

Among those most affected by the low water levels are the shipping companies that operate massive, 1,000-foot-long iron ore and coal carriers on the Great Lakes. Low water levels can force these cargo ships to lighten their loads by as much as 6,000 tons to reduce their drafts and avoid running aground in channels and ports. Also, in recent years, ferry services that transport people to and from islands have been forced to shut down because of low water depths. Significant drops in water levels can also result in an increase in demand for dredging projects, which can be very expensive. In addition to the high cost of the dredging itself, homeowners and marina operators are faced with the cost of safely disposing of sediments that have been contaminated with heavy metals, pesticides, diesel fuel and other toxic substances. Under strict environmental laws, such dredged material has to be deposited in confined disposal facilities.

Significant Shoreline Hazard Events in Michigan

November 11, 1940 – Lake Michigan Seiche

Enormous waves were generated by a huge storm system, with winds blowing in from the southwest and reaching speeds of up to 75 mph. The northern shore of Lake Michigan was reported to have sustained considerable damage from the push of water during the resulting seiche. Five vessels and 66 lives were lost (including 57 deaths from the sinking of two freighters that are also listed in the Transportation Incidents section of this document). A car ferry was damaged and driven ashore at Ludington.

May 31, 1998 – Lake Michigan Seiche

A derecho produced widespread wind gusts of 60 to 90 miles per hour and moved across Lake Michigan, causing the sinking of a tugboat north of Muskegon (in White Lake Channel north of Wabaningo). Repairs for the boat were estimated at $20,000. Consumers Energy reported more than 600,000 customers without power, marking the most destructive weather event in the company's history. It took up to 10 days to restore power to all areas. Although most of the damages, deaths, and injuries in this storm system were caused by other storm effects, one component was the wave action that took its toll just north of Muskegon.

July 4, 2006 – Berrien County Rip Current

Wave on Lake Michigan ranged from 2 to 6 feet and allowed for several rip current occurrences near Berrien County shores. County officials conducted at least 6 rescues, despite numerous warnings and advisories having been announced. 4 persons were treated at beaches, but 1 rescued woman died several days later.

October 28-29, 2006 – Lake Erie Seiche

After two days of wind blowing at speeds of 30 to 40 mph, the difference in water levels between one end of Lake Erie and the other reached 8 feet. Fortunately, the seiche caused a drop rather than a rise of waters along Michigan's coastline, but this can still cause a weakening and erosion of shoreline areas. The waters at Monroe were 4 feet below the level they had been at merely two days before, on October 27.

August to September 2007 – Muskegon County Water Level Recession

Local reports described drought-related effects upon marine traffic in the Muskegon area. A super-freighter became stuck in the mouth of Muskegon Harbor and was reported as the second large ship to run aground within the space of a month, in the same location. Shipping officials stated that additional dredging was needed in Great Lakes ports because of low water levels.

August 15, 2009 – Mackinac County Rip Current

Onshore winds and significant wave action resulted in rip currents on the far northern beaches of Lake Michigan. Two persons died near the Pointe Aux Chemes sand dunes (about 10 miles northwest of St. Ignace), when a 16-year-old teen was carried into deeper water by currents, and his 66-year-old grandfather attempted to rescue him. Both were overcome by waves and currents, and revival attempts were unsuccessful when the two were finally retrieved.

August 5, 2010 – Rip Currents (Marquette and Alger Counties)

Two teenaged swimmers drowned in high waves and rip currents near Presque Isle (Marquette County), where winds gusted to over 30mph at times. In Grand Marais Harbor (Alger County), a father and son both drowned in similar high waves, winds, and rip currents.

September 3, 2010 – Berrien County Rip Current

Strong winds created dangerous conditions on far southeastern Lake Michigan, where waves as high as 16 feet caused extremely strong rip currents. A man from Chicago drowned after he became separated from a rubber raft (which saved his two companions), and was swept out into deeper waters. Numerous agencies attempted to find and rescue the man, but lake conditions caused a rescue craft to capsize, injuring four rescue workers and causing the search mission to be called off.

October 15, 2011 – Berrien County High Surf

One person died when a kayak capsized inside a New Buffalo break-wall, amidst waves of 8 to 10 feet (cresting to 14 feet at the shoreline). Strong winds had caused these rough waters to arise. Two teenaged kayakers were rescued, but the third was lost underwater.

Programs and Initiatives

Michigan Shoreline Flood and Erosion Hazard Regulatory Authority

Shorelands Protection and Management, Part 323 of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended – Part 323 is designed to provide protection to Michigan's Great Lakes shoreline. While these fragile and dynamic shorelines are desirable vacation and recreational areas, they also present inherent hazards to development and are vulnerable to the effects that development often brings. Part 323 gives the MDEQ responsibility to identify hazardous and fragile coastal areas, to establish regulations designed to minimize the impact of development on these areas, and to minimize risks facing new developments. Part 323 identifies three coastal areas: 1) high-risk erosion areas – those shorelines identified as receding at an average long-term rate of at least one foot per year; 2) flood risk areas – those coastal areas that are vulnerable to Great Lakes flooding; and 3) environmental areas – those coastal areas necessary for the preservation and maintenance of fish and wildlife. Regulations have been developed for the unique management issues facing each area.

Mechanisms provided in the law to accomplish this protection are state-developed zoning ordinances, special studies, plans, and remedies for violation of rules. The Act gives the MDEQ the authority to identify and regulate high-risk erosion, flood, and environmental areas using setbacks, zoning, and building code standards. Permits are required for construction in high-risk erosion or flood areas, or for alterations in an environmental area. If a local ordinance has been approved by the MDEQ, the regulation will be done at the local level. In the absence of a local ordinance, permits must be obtained from the MDEQ.

In high-risk erosion areas, the Administrative Rules for the Act require: 1) a 30-year setback for small, readily moveable permanent structures having a foundation size of 3,500 square feet or less; 2) a 60-year setback for all other permanent structures; and 3) all proposed structures of 3,500 square feet or less located within the 60-year setback must be readily moveable. The readily moveable provision expands the options a property owner may economically consider if the home is ever threatened with erosion damage. High-risk erosion areas can be identified through the lists and maps available at http://michigan.gov/deq/0,1607,7-135-3307_3331-107407--,00.html.

In flood risk areas, the Administrative Rules require that (1) residential structures must have the lowest portion of all floor joists located at or above the 100 year flood elevation and (2) any additions to existing structures must be elevated above the 100 year flood elevation.

Environmental areas are portions of the Great Lakes shorelands that have been determined to be necessary for the preservation and maintenance of fish and wildlife. Within environmental areas, permits are required for any dredging, filling, grading, other alteration of soil, vegetation, construction of permanent structures, and natural drainage.

National Flood Insurance Program

For many years, the strategy for reducing flood damages followed a structural approach of building dams and levees and making channel modifications. However, this approach did not slow the rising cost of flood damage, and did not allow individuals to purchase insurance to protect themselves from flood damage. It became apparent that a different approach was needed.

The National Flood Insurance Program (NFIP) was instituted in 1968 to make flood insurance available in communities that have agreed to regulate future floodplain development. As a participant in the NFIP, a community must adopt regulations that: 1) require any new residential construction within the 100-year floodplain to have the lowest floor, including the basement, elevated above the 100-year flood elevation; 2) allow non-residential structures to be elevated or dry floodproofed (the floodproofing must be certified by a registered professional engineer or architect); and 3) require anchoring of manufactured homes in floodprone areas. The community must also maintain a record of all lowest floor elevations or the elevations to which buildings in flood hazard areas have been floodproofed. In return for adopting floodplain management regulations, the federal government makes flood insurance available to the citizens of the community. In 1973, the NFIP was amended to mandate the purchase of flood insurance, as a condition of any loan that is federally regulated, supervised or insured, for construction activities within the 100-year floodplain.

As of December, 2010, there were 25,555 flood insurance policies in force in Michigan, which amounts to almost $3 billion worth of coverage. Officials from FEMA and the MDEQ estimate that only 15% of all floodprone structures in Michigan eligible to purchase flood insurance actually have flood insurance. Furthermore, since only about 49% of the communities in Michigan participate in the NFIP, there are thousands of structures that are floodprone, but are not eligible to purchase flood insurance. (There were 867 participating communities as of December 22, 2010, and another 108 communities that were mapped but not participating—probably since the mapping was recently completed under FEMA's Map Modernization program.)

For more information about the participation of Michigan communities in the NFIP and CRS, please refer to the preceding chapter about Riverine Flooding.

Community Education

The MDEQ periodically holds workshops for lenders, realtors, insurance agencies, citizens and any other interested parties. The workshops provide a wide variety of information tailored to the specific group(s). Topics typically include building code requirements, other state and federal regulations, floodplain management programs, and the responsibilities of involved parties such as local governments, lending institutions, citizens, etc. Staff from the MDEQ will also meet with property owners onsite to discuss shoreline flooding and erosion problems and possible solutions based on the specifics of the property.

National Weather Service Watches/Warnings

In 2005, The National Weather Service announced that it would start issuing Coastal Flood Warnings for the Lower Peninsula shorelines of Lake Michigan and Lake Huron using a model that calculates such factors as wind speed, wave height, and time between waves. Advisories that warn when conditions present an increased risk of rip currents will be posted on the agency's web site and shared with weather broadcasters.

State-Administered Shoreline Hazard Mitigation Programs

In 1986, in response to the Great Lakes shoreline flooding and erosion problems, the State of Michigan established three unique shoreline hazard mitigation programs designed to prevent or minimize damage and impact caused by shoreline flooding and erosion. (Note: These temporary programs were established only for the 1985-86 high water period. They have since been closed out and are no longer available.)

The **Shoreline Community Protection Program** provided grants for community shoreline damage prevention efforts. From 1986 through 1988, the program provided support for flood and erosion mitigation projects undertaken by local governments in the form of grants which would cover 85% of the cost of projects. Four hundred seventy one (471) grants were awarded, totaling approximately $4.2 million.

Two interest-rate buy-down programs, the **Emergency Home Moving Program** and **Emergency Flood Protection Program**, were established on a temporary basis to encourage a non-structural approach to erosion and flood hazards during the 1985-86 high water levels on the Great Lakes. The programs provided a lump sum payment equaling 3% of the interest rate of the secured loan amount for projects to move houses away from the eroding bluff line or elevate homes in floodprone areas. From 1986 through 1988, a total of $2 million was made available to interested homeowners. A total of 72 structures were relocated under the program, and 43 were elevated.

USACE Advance Measures Program

The USACE Advance Measures Program can be implemented to assist a state or local government in mitigating the potential damage and impact caused by flooding. Under the Advance Measures Program, the Army Corps of Engineers may provide "self-help" materials (i.e., sandbags, sand, and plastic sheeting), at 100% federal cost, to participating units of government for use in direct pre-flood mitigation activities. An example of a self-help project would be the construction of temporary sandbag dikes. The Advance Measures Program also has a construction component under which the Corps can provide assistance with permanent construction projects designed to mitigate potential flood damages. Such projects are funded on a 75% federal and 25% local cost-share basis. Construction projects require a written cooperation agreement between the Corps and the participating jurisdiction. The jurisdiction must agree to furnish all land, easements and rights-of-way, agree to operate and maintain the project for 25 years, pay the 25% project cost-share, and provide interior drainage. Examples of construction projects that could potentially be funded under this component of the program include earthen levees, rock and/or sand-filled cribs, and concrete and/or steel sheetpile seawalls.

The Advance Measures Program and its predecessor, Operation Foresight, has been implemented during the last three high water periods on the Great Lakes. Over 100 flood mitigation projects have been funded under these programs in Michigan and other Great Lakes states over the last three decades. In response to the high lake levels in 1972-73, the Corp's Operation Foresight program provided over $13.5 million in funds for self-help and flood mitigation construction projects. During the 1985-86 high water period, total project costs for self-help and construction projects under the Advance Measures Program exceeded $12.5 million. In the most recent high water period (1997-98), in response to request by the Governor, the USACE provided approximately one million self-help sandbags, and worked with seven communities to complete eight Advance Measures construction projects. Those projects are located on or adjacent to Lake Erie, Lake St. Clair, and Saginaw Bay.

Great Lakes Shoreline and Wetlands Task Force Report

A special task force was assembled to study state and federal regulations on wetlands and to develop recommendations for the regulatory agencies to allow shoreline property owners access to their waterfront while maintaining the ecological value of the areas. The report identified areas of inconsistency in existing Army Corps of Engineers and Michigan Department of Environmental Quality (MDEQ) permitting processes and recommended that the agencies work together to alleviate the inconsistencies. The report identified and listed the activities that shoreline property owners can undertake without requiring a permit from either the state or federal regulatory agency. The report is available at www.lre.usace.army.mil.

The Great Lakes Beach and Pier Safety Campaign

The Great Lakes Beach and Pier Safety Campaign is a collaborative effort between multiple agencies and organizations from Michigan, Illinois, Pennsylvania, and Ohio. It is a comprehensive approach to addressing the lack of education and understanding of rip currents and the dangers they present during storms on the Great Lakes. The campaign was developed by The Great Lakes Beach and Pier Safety Task Force, which has produced an educational video on rip currents entitled "Respect the Power." The task force, along with assistance from State Farm Insurance, has mailed out 3,000 copies to all of the middle schools, high schools, and public libraries in Michigan.

Other State and Federally-Assisted Flood Mitigation Projects

The State of Michigan has used a variety of federal funding sources to assist in the implementation of flood mitigation projects. Those funding sources have included: 1) the Hazard Mitigation Grant Program (HMGP); 2) the Flood Mitigation Assistance Program (FMAP); 3) the Pre-Disaster Mitigation Program (PDMP); 4) the Public Assistance Grant Program (PAGP); 5) the Individual and Family Grant Program (IFGP) – no longer in existence; 6) the National Flood Insurance Program, Section 1362 (no longer in existence); 7) Community Development Block Grants (CDBG); and 8) Farmers Home Administration (FmHA) loans. State and local funds have been used to match the federal sources of funding.

Coastal Management Program

The Coastal Zone Management Act (CZMA), originally passed in 1972, enables coastal states, including Great Lakes states, to develop a coastal management program to improve protection of sensitive shoreline resources, to identify coastal areas appropriate for development, to designate areas hazardous to development, and to improve public access

to the coastline. Michigan was among the first states to have its coastal program approved in 1978. The program is administered by the Administration Section of the Environmental Science and Services Division (ESSD) of the MDEQ. The program includes local pass-through grants and administration of coastal related sections of the Natural Resource and Environmental Protection Act, 1994 PA 451. Review of federal agency activities (for consistency with Michigan's approved program) is performed by the Great Lakes Shorelands Section in the Land and Water Management Division (LWMD) of the MDEQ.

Hazard Mitigation Alternatives for Shoreline Flooding and Erosion

- Floodplain/coastal zone management – planning acceptable uses for areas prone to flooding (comprehensive planning, zoning, open space requirements, subdivision regulations, land use and capital improvements planning).
- Dry floodproofing of structures within known flood areas (strengthening walls, sealing openings, use of waterproof compounds or plastic sheeting on walls).
- Wet floodproofing of structures (controlled flooding of structures to balance water forces and discourage structural collapse during floods).
- Elevation of flood-prone structures above the 100-year flood level.
- Construction of elevated or alternative roads that are unaffected by flooding, or making roads more flood-resistant through better drainage and/or stabilization/armoring of vulnerable shoulders and embankments.
- Government acquisition, relocation, or condemnation of structures within floodplain or floodway areas.
- Employing techniques of erosion control in the area (bank stabilization, planting of vegetation on slopes, creation of terraces on hillsides).
- Enforcement of basic building code requirements related to flood mitigation.
- Joining the National Flood Insurance Program, obtaining insurance, and participating in the Community Rating System (CRS).
- Structural projects to channel water away from people and property (dikes, levees, floodwalls) or to increase drainage or absorption capacities (spillways, water detention and retention basins, relief drains, drain widening/dredging or rerouting, debris detention basins, logjam and debris removal, extra culverts, bridge modification, dike setbacks, flood gates and pumps, wetlands protection and restoration).
- Elevating mechanical and utility devices above expected flood levels.
- Flood warning systems.
- Monitoring of water levels with stream gauges and trained monitors.
- Anchoring of manufactured homes to a permanent foundation in flood areas, but preferably these structures would be permanently relocated outside of flood-prone areas and erosion areas.
- Control and securing of debris, yard items, or stored objects in floodplains that may be swept away, damaged, or pose a hazard when flooding occurs.
- Increased coverage and use of NOAA Weather Radio.

Tie-in with Local Hazard Mitigation Planning

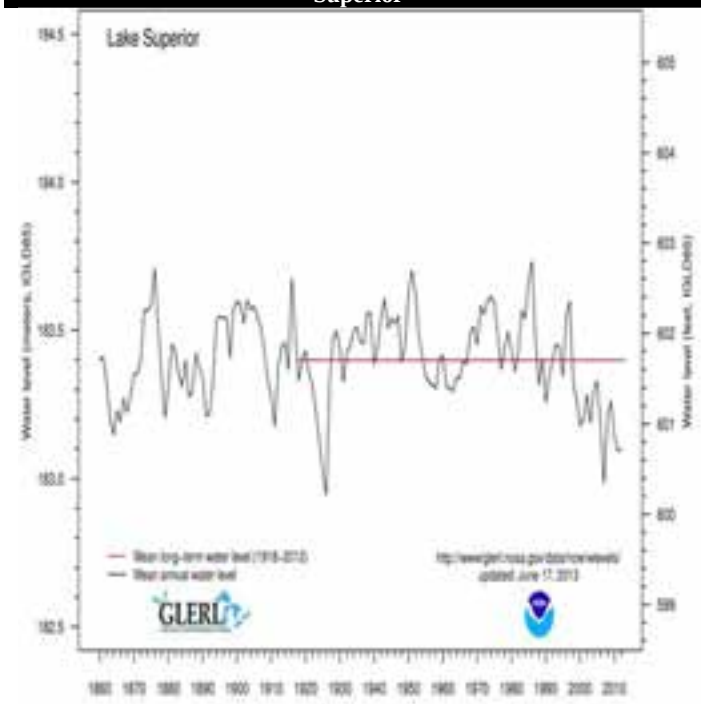
Because many means of implementing mitigation actions occur through local activities, this updated MHMP places additional emphasis on the coordination of State-level planning and initiatives with those taking place at the local level. This takes two forms:

1. The provision of guidance, encouragement, and incentives to local governments by the State, to promote local plan development (including a consideration of shoreline flooding and erosion conditions), and
2. The consideration of information contained in local hazard mitigation plans when developing State plans and mitigation priorities.

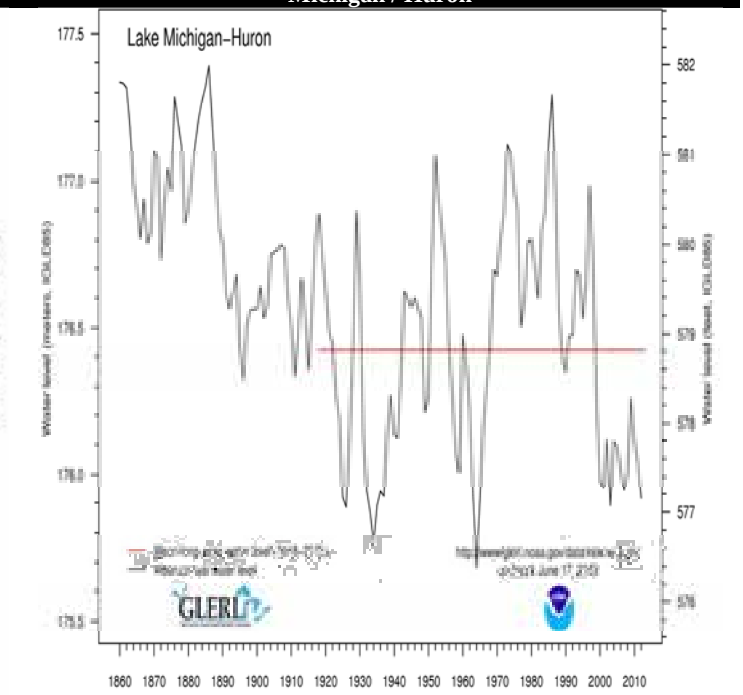
Regarding the first type of State-local planning coordination, MSP guidance has included the “Local Hazard Mitigation Planning Workbook” (EMD-PUB 207), which is currently being updated for release by 2015. For the second type of State-local planning coordination, a section later in this plan summarizes hazard priority information as it has been reported in local hazard mitigation plans. Here, it will merely be noted that shoreline hazards were identified as some of the most significant hazards in local hazard mitigation plans for the following counties: Antrim, Baraga, Bay, Benzie, Emmet, Grand Traverse, Houghton, Keweenaw, Leelanau, Luce, Macomb, Manistee, and Menominee.

Great Lakes Water Levels Since 1860
(Plus Lake St. Clair Since 1900)
Measurements are in meters

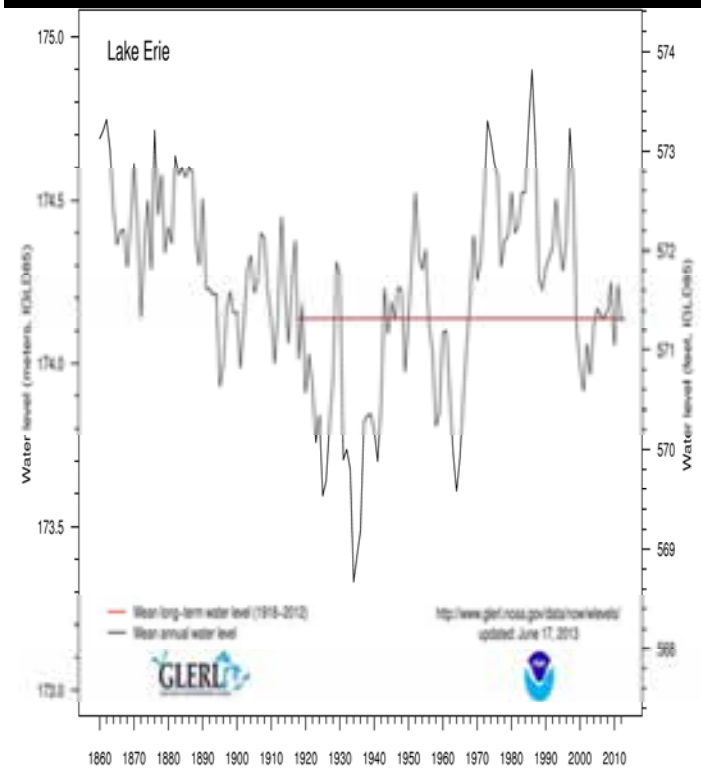
Superior



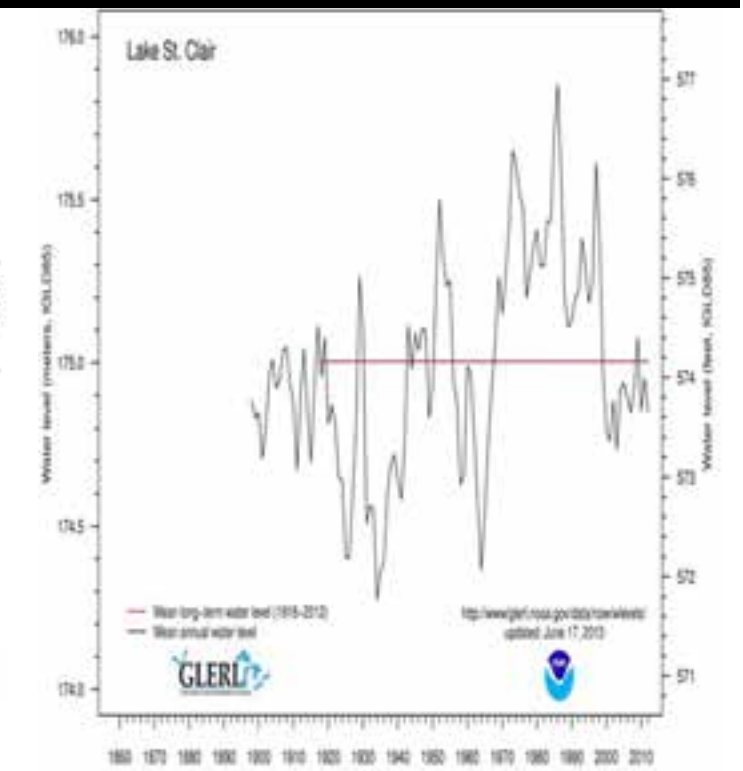
Michigan / Huron



Erie



Lake St. Clair



Source: National Oceanic and Atmospheric Administration hydrographs from http://www.glerl.noaa.gov/data/now/wlevels/levels.html

Shoreline Hazard History for Michigan Counties – arranged by region – Jan. 1996 to Oct. 2013
(The Lower Peninsula regions are ordered by "tiers" from south to north, west to east)
Please refer to the Michigan Profile Map section for an explanation of regional divisions

COUNTY or area	**Shoreline Events**	**Days with Shoreline Hazards**	**Tot. property damage**	**Injuries**	**Deaths**
Washtenaw					
Wayne					
.Livingston					
Oakland					
Macomb					
5 Co Metro region					
Berrien	17	17		8	15
Cass					
St. Joseph					
Branch					
Hillsdale					
Lenawee					
Monroe					
.Van Buren					
Kalamazoo					
Calhoun					
Jackson					
.Allegan	1	1			
Barry					
Eaton					
Ingham					
.Ottawa					
Kent					
Ionia					
Clinton					
Shiawassee					
Genesee					
Lapeer					
St. Clair					
.Muskegon	1	1	$20,000		
Montcalm					
Gratiot					
Saginaw					
Tuscola					
Sanilac					
.Mecosta					
Isabella					
Midland					
Bay					
Huron					
34 Co S Lower Pen	**0.56 avg.**	**0.56 avg.**	**$20,000**	**8**	**15**

Continued on next page…

Part 2 of Michigan County Shoreline Hazards History Table

.Oceana					
Newaygo					
.Mason					
Lake					
Osceola					
Clare					
Gladwin					
Arenac					
.Manistee	1	1			1
Wexford					
Missaukee					
Roscommon					
Ogemaw					
Iosco					
.Benzie	2	2		1	1
Grand Traverse					
Kalkaska					
Crawford					
Oscoda					
Alcona					
.Leelanau	1	1			1
Antrim					
Otsego					
Montmorency					
Alpena					
.Charlevoix					
Emmet	1	1			1
Cheboygan					
Presque Isle					
29 Co N Lower Pn	**0.17 avg.**	**0.17 avg.**		**1**	**4**
Gogebic					
Iron					
Ontonagon					
Houghton	1	1			
Keweenaw	1	1			
Baraga	1	1			
.Marquette	6	6			5
Dickinson					
Menominee					
Delta					
Schoolcraft					
Alger	3	3			
.Luce	1	1			
Mackinac	1	1			2
Chippewa					
15 Co Upp.Pen	**0.39 avg.**	**0.39 avg.**			**7**
MICHIGAN TOTAL	**36**	**34**	**$20,000**	**9**	**29**

NOTE: Some qualifying shoreline events have been classified by NCDC under other hazards, such as flooding. This table is not considered to be fully representative of the impacts of the shoreline erosion hazard, but more representative of the impact of rip currents and high tide hazards.

Michigan Great Lakes Shoreline Erosion Hazard Areas

Source: Michigan Department of Environmental Quality web site at http://michigan.gov/deq/0,1607,7-135-3307_3331-107407--,00.html

Dam Failures

The collapse or failure of an impoundment that results in downstream flooding.

Hazard Description

A dam failure can result in loss of life, and in extensive property or natural resource damage for miles downstream from the dam. Dam failures occur not only during flood events, which may cause overtopping of a dam, but also as a result of poor operation, lack of maintenance and repair, and vandalism. Such failures can be catastrophic because they occur unexpectedly, with no time for evacuation. The Michigan Department of Environmental Quality (MDEQ) has documented approximately 287 dam failures in Michigan since 1888.

The federal levee database for the State of Michigan is provided on the map below. In addition, the following is a list of some areas known to the Water Resources Division of the MDEQ. This listing is for informational purposes only, to comply with federal recommendations for hazard analysis, and the listing of an area is not intended to suggest any specific risk or vulnerability in the vicinity at this time.

Information on dams with low hazard potential may be available from the National Inventory of Dams. As of 2012, 136 of the dams in Michigan were classified as "high hazard" (meaning there was at least some development downstream, in the dam's "hydraulic shadow"), down from the count of 161 from just a few years before. Development should be discouraged in areas that would increase the risks from potential dam failures. Effects from dam failures can be more severe than those from riverine flooding, due to the possibility of the extra effects of flash flooding and wave action from a catastrophic dam failure.

Hazard Analysis

The worst recorded dam failure in U.S. history occurred in Johnstown, Pennsylvania on the afternoon of May 31, 1889. More than 2,200 persons were killed when the South Fork Dam on the Conemaugh River upstream from Johnstown failed, sending 20 million tons of water downstream in a huge wall of water (at times 60-70 feet high) moving at 40 miles per hour. The wall of water, laden with debris, hit Johnstown within an hour, completely inundating the town and crushing everything in its path. The flood was over in 10 minutes, but the effects were felt for years to come. The cause of this catastrophic failure was later determined to be inadequate maintenance of the South Form Dam by the South Fork Fishing and Hunting Club – a private lake association who counted among its members wealthy Pittsburgh steel and coal industrialists such as Andrew Carnegie and Andrew Mellon. The Conemaugh Valley was again the site of dam failures in May of 1977 when nearly 12 inches of rain fell in a 10-hour period, causing six dams surrounding Johnstown to fail. These six failures poured more than 128 million gallons of water into the Conemaugh Valley, resulting in the deaths of 45 persons and heavy property losses. The storm event that caused the dam failures was said to be a once in a 5,000 to 10,000 year occurrence.

Some Michigan areas with levees, or similar structures:

Village of Clinton	Along the River Raisin in Lenawee County
City of Detroit	A series of "seawalls" may be providing some protection
East China Township (St. Clair Co.)	Several ring dikes are shown on the community's map
City of Frankenmuth	USACE flood-control project on the Cass River
Cities of Grand Rapids and Walker	Floodwalls along the Grand River
City of Grosse Pointe Park	Sea wall along the Detroit River and Lake St. Clair
Hampton Township (Bay Co.)	Coastal levee
Kalamazoo City and Township	Levees surrounding waste disposal ponds
City of Manistique	One dam includes a flume that may have levee-like functions
Saginaw County	Low-level dikes along the Flint River in Albee, Spaulding, and Taymouth Townships
Saginaw County	Low-level dikes along the Cass River in Bridgeport and Spaulding Townships
Sebewaing (Huron Co.)	USACE flood-control project
Village of St. Charles (Saginaw Co.)	Levee
Wisner Township (Tuscola Co.)	Dikes

Dams are important components of the state's infrastructure and provide benefits to all citizens. However, as history has demonstrated, dams can fail with disastrous consequences, causing unfortunate loss of life and property and natural resources. Many existing dams are getting older, and new dams are sometimes built in developed areas. At the same time, development continues in potential inundation zones downstream from dams. More people are at risk from dam failure than ever before, despite better engineering and construction methods. As a result, continued loss of property can be expected to occur. The challenges facing local emergency management officials are: 1) minimize loss of life and property by working closely with dam owners in the development of the EAPs to ensure consistency with the Emergency Operations Plan (EOP) for the jurisdiction; 2) developing procedures in the EOP for responding to a dam failure (including a site-specific standard operating procedure for each dam site); 3) participating in dam site exercises; and 4) increasing public awareness of dam safety procedures.

The risk of dam failures should be calculated, where possible, from past occurrences. If a community has had no history of dam failures, the community may wish to examine the histories of similar types of dams (based on size, construction, ownership, maintenance schedules) and use that information to estimate the annual chance of a failure. Remember that not all failures result in damaging floods—many failures are caught in time to prevent flood damages, but still have costs associated with emergency response and repairs. It makes sense to calculate costs from different types of events. In most years, there will be no incident. If there is an incident, it may be relatively minor in its impact. The worst case scenario would involve catastrophic dam failure.

Federal and State laws require the owners of high and significant hazard potential dams to prepare and keep current an Emergency Action Plan for their dams. They are also required to submit such plans to their local emergency management officials and/or Dam Safety Officer for review and coordination. The EAP includes mapping and/or listing of buildings that would be inundated in the event of dam failure.

Information on dams with low hazard potential may be found in the National Inventory of Dams. Most dams in Michigan, have not been classified as having "high hazard" potential, although that designation technically refers to the fact that at least some development exists downstream, in the dam's "hydraulic shadow"). Development should be discouraged in areas that would increase the risks from potential dam failures. Effects from dam failures can be more severe than those from riverine flooding, due to the possibility of the extra effects of flash flooding and wave action from a catastrophic dam failure.

The actual risk of dam failures in general needs to be calculated from fairly rare past occurrences. Not all dam failures result in damaging floods—many failures are caught in time to prevent flood damages, but still have costs associated with emergency response and repairs. In most years, there will be no incident. If there is an incident, it tends to be relatively minor in its impact. Although none of the 287 recorded dam failures in Michigan were truly catastrophic in terms of massive loss of life, property damage from major events has sometimes been very significant, particularly in terms of the related flooding that tends to follow a dam failure. Millions of dollars of damage resulted from the 2002 to 2004 events in the Upper Peninsula, which were the largest recent events of this type. Although dams vary widely in their significance and environmental context throughout Michigan, the historical record shows a frequency of about 2.3 failures per year, on average, with most involving small impacts and rural locations.

Impact on the Public

No catastrophic dam failures have been reported in Michigan, of a type that actually had unanticipated flash-flood style impacts on anyone who might have been affected by them. However, significant dam failure events have occurred and caused displacement, infrastructure failure, road/bridge closures, and property damage. The impacts have generally been similar to those of riverine flooding (please see that chapter in this analysis), except that dam failures present the possibility for a faster release and inundation of the affected areas, and that failed dams may affect the area's hydrology and infrastructure. (For example, hydroelectric dams may need to be shut down in the event of a breach, causing impacts on the power supply of an area, or local economic effects.)

Impact on Public Confidence in State Governance

Recorded dam failures in Michigan have not been catastrophic, but still may cause problems in residents' perceptions of the reliability of government standards and policy regarding the engineering, inspection, and maintenance of such structures. The failure of levies in the New Orleans hurricane event may carry over into more general concerns about the adequacy of structural water containment infrastructure nationwide.

Impact on Responders

Some dam failures can cause catastrophic flash flooding to take place, which is especially dangerous to any who are near the floodway area, as responders often must be. In addition, access to dam areas is often made difficult by their remoteness, the presence of barbed wire, hunting areas, rugged terrain, etc.

Impact on the Environment

Dam failure has the potential to cause great harm to the natural ecosystem by pushing sedimentation throughout the floodplain. Dam failure can also push water onto agricultural land, which can then carry fertilizers and pesticides into other areas.

Significant Dam Failures in Michigan

1939 – Lenawee County

A dam failure occurred in Lenawee County when the Rollin Mill Dam was struck by a tornado in 1939. The Rollin Mill Dam was not rebuilt after being destroyed in the incident.

September 1986 – Central Lower Peninsula

On September 10 - 11, 1986 an intense rainstorm in the central portion of the Lower Peninsula produced rainfall amounts ranging from 8 to 17 inches over an area 60 miles wide and 180 miles long. As a direct result of that storm, 11 dams failed and 19 others were threatened with failure, resulting in about 1,500 people being evacuated downstream of the dams. The failure and threatened failure of these dams was primarily the result of inadequate spillway capacity. Most of the dams were constructed without an emergency spillway, and didn't have an adequate inspection and maintenance program. The excessive rainfall resulted in the design capacity of the dam being exceeded, causing failure of the dam or intentional breaching of the embankment to save certain portions of the structure. Fortunately, no deaths or injuries were attributable to this series of dam failures.

2002 to 2004 – Upper Peninsula Flooding and Dam Failures

A pattern of flooding and dam failures occurred in the Western and Central Upper Peninsula for several years in a row. In April of 2002, several dams in Gogebic County were breached by floodwaters, with the City of Wakefield being especially affected. The city's water treatment, wastewater treatment, and electric plant were all in danger of inundation and shutdown, and the State Police Post there was evacuated due to flooding. The Wood Dam (Presque Isle Wildlife Dam) was breached and an embankment to its north partially eroded, allowing waters to flow through. In Gogebic County, 48 homes were destroyed, 91 suffered major damage, and 27 endured minor damage; 7 businesses were destroyed, and 11 were damaged. A federal Disaster Declaration was issued by the president.

In Marquette County, two dams were at maximum levels, but held during that 2002 event. In May of the next year, however, Marquette County was the one to suffer from flooding, as a series of dikes and dams failed, starting with the Silver Lake dike, and caused excessive water to flood low-lying areas in the City of Marquette. Marquette County declared a local state of emergency, and damages were estimated at about $3.2 million, of which $1,000,000 was caused to the failed dike and downstream dams themselves. The Governor ordered the evacuation of persons living along waterways in the Dead River Basin area and its tributaries downstream of Silver Lake. Although the U.S. Small Business Administration issued a "Declaration of Economic Injury," no federal Disaster Declaration was approved for this event.

In 2004, similar flooding threatened to occur, but did not have quite the same level of impact as had happened in the previous two years.

October 6, 2012 – Dam Failure and Flash Flood (Grand Traverse County)

East of the town of Grawn, a temporary dam and de-watering structure had been in place alongside the Brown Bridge Dam on the Boardman River, to assist in drawing down the small lake behind the dam (Brown Bridge Pond) before the dam's permanent removal. This temporary dam failed and caused the release of all remaining water, causing road closures and home evaluations within the hour. A total of 53 homes sustained varying degrees of damage. Docks, small footbridges, and some small outbuildings were destroyed. Total damages were estimated at $1.8 million.

Historically Significant Dam Failures across the U.S. (selected events before 1990)

Year	Dam Name / Location	Deaths
1874	Mill River, Massachusetts	143
1890	Walnut Grove, Arizona	150
1899	Johnstown, Pennsylvania	2,209
1911	Bayless, Pennsylvania	80
1928	St. Francis, California	450
1972	Black Hills / Canyon Lakes, South Dakota	278
1972	Buffalo Creek, West Virginia	125
1976	Teton, Idaho	11
1976	Big Thompson River, Colorado	144
1977	Tocca Falls, Georgia	39
1977	Laurel Run / Shady Run, Pennsylvania	45
1978	Texas Hill Country, Texas	25
1990	Shadyside, Ohio	24

Sources: National Performance on Dams Program, Center on Performance of Dams, Stanford University, (M. McCall), 1995; *Multi-Hazard Identification and Risk Assessment*, 1997, FEMA.

Programs and Initiatives

The series of tragic dam failures that occurred across the United States in the 1970s prompted government action to more stringently regulate dams and heightened public concern about hazards created by unsafe dams. Both the MDEQ and the Federal Energy Regulatory Commission (FERC) classify and regulate dams in Michigan. Under state and federal legislation, certain dam owners are required to develop a survey of the downriver area, develop flood-prone area maps and develop emergency action plans (EAPs). Furthermore, the FERC requires the owners of such dams to exercise these plans; the MDEQ has initiated an effort to encourage owners of state-regulated dams to voluntarily perform exercises of their EAPs. In Michigan, well over 100 dams are covered by Emergency Action Plans.

Dams in Michigan are regulated by Part 315 of The Natural Resources and Environmental Protection Act, 1994 PA 451, as amended. Part 315, Dam Safety provides for the inspection of dams. This statute requires the MDEQ to rate each dam as either "high," "significant," or "low" hazard potential, according to the potential downstream impact if the dam were to fail (not according to the physical condition of the dam). The MDEQ has identified and rated over 2,400 dams. Dams over 6 feet in height that create an impoundment with a surface area of 5 acres or more are regulated by this statute. Dam owners are required to maintain an EAP for "high" and "significant" hazard potential dams. Owners

are also required to coordinate with local emergency management officials to assure consistency with local emergency operations plans. Dams regulated by FERC, such as hydroelectric power dams, are generally exempt from this statute.

The FERC licenses water power projects (including dams) that are developed by non-federal entities, including individuals, private firms, states and municipalities. Under provisions of the Federal Power Act and federal regulations, the licensee of the project must prepare an EAP. This plan must include a description of actions to be taken by the licensee in case of an emergency. Inundation maps showing approximate expected inundation areas must also be prepared. Licensees must conduct a functional exercise at certain projects, in cooperation with local emergency management officials.

Recognizing the importance of mitigating dam failures, the State of Michigan in recent years has used federal grant funds for several projects designed to reduce local vulnerability to dam failures by upgrading dams or removing persons from harm's way.

The federal Dam Safety and Security Act of 2002 addresses safety and security of dams through the coordination by the Federal Emergency Management Agency (FEMA) of federal programs and initiatives for dams and the transfer of federal best practices in dam security to the states. The Act includes resources for the development and maintenance of a national dam safety information network and the development by the National Dam Safety Review Board of a strategic plan that establishes goals, priorities, and target dates to improve the safety and security of dams in the United States.

The Act continues all of the programs established by the 1996 Act that have been serving to increase the safety of the nation's dams, including: 1) increased funding authority to support improvement of the state dam safety programs that regulate over 77,000 dams in the United States; 2) the work of the Interagency Committee on Dam Safety (ICODS); 3) the development of the strategic plan and the biennial report on the National Dam Safety Program; 4) training for state dam safety staff and inspectors; 5) a continued program of technical and archival research, including the development of devices for the continued monitoring of the safety of dams; and 6) increased reliance on the National Dam Safety Review Board, which provides the Director of FEMA with advice on national policy issues affecting dam safety and helps oversee the operation of state dam safety programs.

Hazard Mitigation Alternatives for Dam Failures

- Regular inspection and maintenance of dams.
- Garnering community support for a funding mechanism to assist dam owners in the removal or repair of dams in disrepair.
- Regulate development in the dam's hydraulic shadow (where flooding would occur if a severe dam failure occurred).
- Ensuring that dams meet or exceed the design criteria required by law.
- Public warning systems.
- Obtaining insurance.
- Increased coverage and use of NOAA Weather Radio
- Increased funding for dam inspections and enforcement of the Dam Safety Program (Part 315 of the Natural Resources and Environmental Protection Act) requirements and goals.
- Constructing emergency access roads to dams, where needed.
- Pump and flood gate installation/automation.

Tie-in with Local Hazard Mitigation Planning

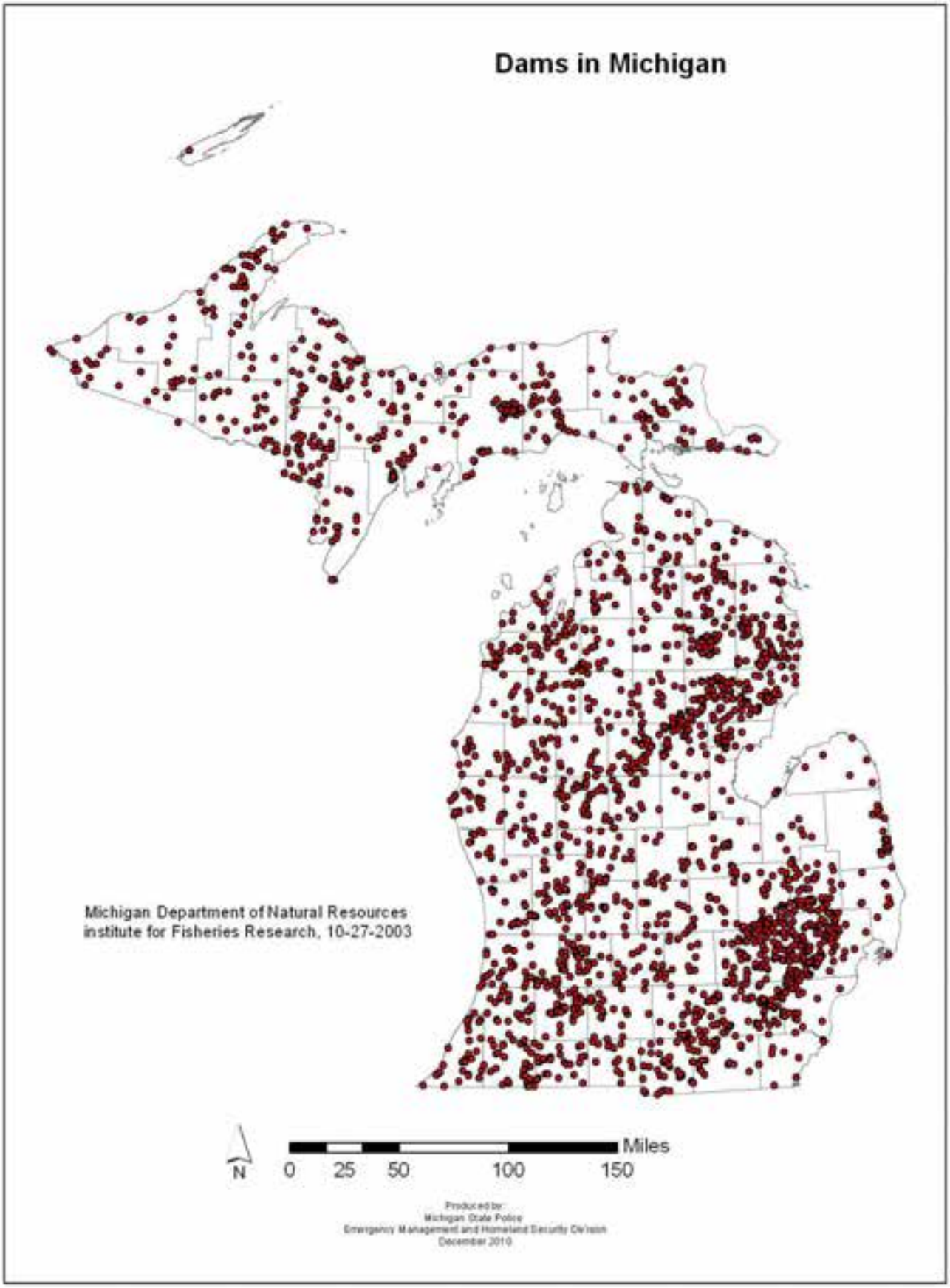
Because many means of implementing mitigation actions occur through local activities, this updated MHMP places additional emphasis on the coordination of State-level planning and initiatives with those taking place at the local level. This takes two forms:

1. The provision of guidance, encouragement, and incentives to local governments by the State, to promote local plan development (including a consideration of dam failures), and
2. The consideration of information contained in local hazard mitigation plans when developing State plans and mitigation priorities.

Regarding the first type of State-local planning coordination, MSP guidance has included the "Local Hazard Mitigation Planning Workbook" (EMD-PUB 207), which is currently being updated for release by 2015. For the second type of State-local planning coordination, a section later in this plan summarizes hazard priority information as it has been reported in local hazard mitigation plans. Here, it will merely be noted that dam failures were identified as one of the most significant hazards in local hazard mitigation plans for the following counties: Allegan, Alpena, Calhoun, Eaton, Gladwin, Houghton, Iron, Kalkaska, Leelanau, Manistee, Marquette, Midland, and Roscommon.

Potential Dam Hazards in Michigan
(as of December 2010)

County	High Hazard	Significant Hazard	Total	County	High Hazard	Significant Hazard	Total
Alcona	1		**1**	Lake		2	**2**
Alger	1		**1**	Lapeer	1	6	**7**
Allegan	7	2	**9**	Leelanau	2	1	**3**
Alpena	2	1	**3**	Lenawee	3	5	**8**
Antrim	2		**2**	Livingston	3	7	**10**
Arenac		1	**1**	Luce			**0**
Baraga	2		**2**	Mackinac	1		**1**
Barry		3	**3**	Macomb	2	1	**3**
Bay			**0**	Manistee	2		**2**
Benzie		1	**1**	Marquette	9	7	**16**
Berrien	2	2	**4**	Mason	2		**2**
Branch		1	**1**	Mecosta		4	**4**
Calhoun		3	**3**	Menominee	4	2	**6**
Cass	2	1	**3**	Midland	4		**4**
Charlevoix		3	**3**	Missaukee		1	**1**
Cheboygan	6	3	**9**	Monroe		2	**2**
Chippewa		1	**1**	Montcalm		2	**2**
Clare	3		**3**	Montmorency		2	**2**
Clinton		2	**2**	Muskegon	1	2	**3**
Crawford			**0**	Newaygo	3	1	**4**
Delta	1	1	**2**	Oakland	8	15	**23**
Dickinson	2	3	**5**	Oceana	2	2	**4**
Eaton	3		**3**	Ogemaw		3	**3**
Emmet		1	**1**	Ontonagon	2	2	**4**
Genesee	3	7	**10**	Osceola		1	**1**
Gladwin	5	1	**6**	Oscoda	1		**1**
Gogebic			**0**	Otsego			**0**
Grand Traverse	4	4	**8**	Ottawa	1	1	**2**
Gratiot		2	**2**	Presque Isle			**0**
Hillsdale		5	**5**	Roscommon	1	3	**4**
Houghton		2	**2**	Saginaw	1		**1**
Huron			**0**	St. Clair			**0**
Ingham	1	1	**2**	St. Joseph	5	3	**8**
Ionia	1	1	**2**	Sanilac			**0**
Iosco	4	1	**5**	Schoolcraft	1	1	**2**
Iron	3	2	**5**	Shiawassee		2	**2**
Isabella	1	3	**4**	Tuscola			**0**
Jackson	1	4	**5**	Van Buren	1	1	**2**
Kalamazoo	5	5	**10**	Washtenaw	8	6	**14**
Kalkaska	1		**1**	Wayne	8	1	**9**
Kent	2	5	**7**	Wexford		2	**2**
Keweenaw			**0**	**TOTAL**	**141**	**160**	**301**


Dams in Michigan
Michigan Department of Natural Resources
institute for Fisheries Research, 10-27-2003
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Produced by:
Michigan State Police
Emergency Management and Homeland Security Division
December 2010

Drought

A water shortage caused by a deficiency of rainfall, generally lasting for an extended period of time.

Hazard Description

Drought is the consequence of a natural reduction in the amount of precipitation received over an extended period of time, usually a season or more in length. Drought is a normal part of the climate of Michigan and of virtually all other climates around the world – including areas with high and low average rainfall. In low rainfall areas, drought differs from normal arid conditions in that the extent of aridity exceeds even that which is usual for the climate. The severity of a drought depends not only on its location, duration, and geographical extent, but also on the area's water supply needs for human activities and vegetation. This local variation of drought standards makes the hazard difficult to refer to and makes it difficult to assess when and where one is likely to occur.

Drought differs from other natural hazards in several ways. First, in the lack of an exact beginning and endpoint for a drought, whose effects may accumulate slowly and linger even after the event is generally thought of as being over. Second, the lack of a clear-cut definition of drought can make it difficult to confirm whether one actually exists, and if it does, its degree of severity. Third, drought impacts are often less obvious than other natural hazards, and they are typically spread over a much larger geographic area. Fourth, due primarily to the aforementioned reasons, most communities do not have in place any contingency plans for addressing drought. This lack of pre-planning can hinder support for drought mitigation capabilities that would otherwise effectively increase awareness and reduce drought impacts.

Hazard Analysis

Droughts can cause many severe impacts on communities and regions, including: 1) water shortages for human consumption, industrial, business and agricultural uses, power generation, recreation and navigation; 2) a drop in the quantity and quality of agricultural crops; 3) decline of water quality in lakes, streams and other natural bodies of water; 4) malnourishment of wildlife and livestock; 5) increase in wildfires and wildfire-related losses to timber, homes and other property; 6) declines in tourism in areas with water-related attractions and amenities; 7) declines in land values due to physical damage from the drought conditions and/or decreased economic or functional use of the property; 8) reduced tax revenue due to income losses in agriculture, retail, tourism and other economic sectors; 9) increases in insect infestations, plant disease, and wind erosion; and 10) possible loss of human life due to food shortages, extreme heat, fire, and other health-related problems such as diminished sewage flows and increased pollutant concentrations in surface water.

Although it is difficult to determine when a drought is actually occurring, once a drought is recognized it can be classified within four different categories - meteorological, hydrologic, agricultural, and socioeconomic. A **meteorological** drought is based on the degree of dryness, or the departure of actual precipitation from an expected average or normal amount based on monthly, seasonal, or annual time scales. A **hydrologic** drought involves the effects of precipitation shortfalls on stream flows and reservoir, lake, and groundwater levels. An **agricultural** drought concerns soil moisture deficiencies relative to the water demands of plant life, usually crops. A **socioeconomic** drought is when the effective demand for water exceeds the supply, as a result of weather-related shortfalls.

The U.S. Drought Monitor (http://www.drought.unl.edu/dm/monitor.html) uses four classifications of severity, from the least intense category (D1) to the most intense (D4), with an additional (D0) category used to designate a "drought watch" area in which long-term impacts such as low reservoir levels are probably present. The Drought Monitor summary map is available online, identifying general drought areas and labeling their intensity. While not the only way to characterize droughts, the U.S. Drought Monitor is convenient and their classification levels have recently been used in various reports and assessments of drought conditions. Short-term indicators are on the level of 1-3 months, while long-term indicators focus on durations of 6 to 60 months.

Palmer Drought Classification Categories

Category	Description	Possible Impacts	Palmer Drought Index	CPC Soil Moisture Model, USGS Weekly Streamflow, Objective Short & Long-term Drought Indicator Blends (Percentiles)	Standardized Precipitation Index (SPI)
D0	Abnormally Dry	Going into drought: short-term dryness that slows planting, growth of crops or pastures. Coming out of drought: some lingering water deficits; pastures or crops not fully recovered.	-1.0 to -1.9	21-30	-0.5 to -0.7
D1	Moderate Drought	Some damage to crops, pastures, streams, reservoirs, or wells low; some water shortages developing or imminent; voluntary water-use restrictions requested.	-2.0 to -2.9	11-20	-0.8 to -1.2
D2	Severe Drought	Crop or pasture losses likely; water shortages common; water restrictions imposed.	-3.0 to -3.9	6-10	-1.3 to -1.5
D3	Extreme Drought	Major crop/pasture losses; widespread water shortages or restrictions.	-4.0 to -4.9	3-5	-1.6 to -1.9
D4	Exceptional Drought	Exceptional and widespread crop/pasture losses; shortages of water in reservoirs, streams, and wells creating water emergencies.	-5.0 or less	0-2	-2.0 or less

Source: U.S. Drought Monitor web site http://drought.unl.edu/dm/classify.htm

In addition, the U.S. Drought Monitor uses two general drought categories in assessing an event—an A to denote agricultural effects on crops, pastures, and grasslands, and an H to denote hydrologic effects on water supplies such as rivers, groundwater, and reservoirs.

Despite the thousands of miles of rivers and streams in the state, Michigan has experienced occasional drought conditions. Most common are agricultural droughts, with severe soil-moisture deficits, which have had serious consequences for crop production, particularly when coupled with extreme summer temperatures. Also, various water bodies, both inland lakes and the Great Lakes themselves, cyclically go through periods of low-water levels. Michigan has been in such a period for a number of years now. (See the section on Flooding Hazards: Great Lakes Shoreline Flooding and Erosion for more information about these trends in water levels.)

Recent trends suggest that the pattern in Michigan will continue to be one of low water and lake levels, and even declared declarations of drought. The only exception appears to be the water levels in Lake Erie and Lake St. Clair, which are currently at or above their historically normal levels. (Updated graphs of Great Lakes water levels can be found in the Great Lakes Shoreline Hazards section.) In 2007, all 83 counties received drought disaster declarations from the U.S. Department of Agriculture due to crop losses from drought. In the Muskegon harbor, two freighters became stuck, with low water levels increasing the need for dredging activities and causing ships to unintentionally run aground on the sandy harbor bottom. These events occurred in August and September of 2007, at the same time that drought conditions were present in Michigan. At the beginning of August, three counties (Allegan, Kalamazoo, and Van Buren) were judged to be at D2 (severe drought) status. Twelve other counties in Southwest Michigan were evaluated as having D1 (moderate drought) conditions. Several others were considered to have abnormally dry (D0) status. Wildfire dangers were similarly escalated, due to these dry conditions, with fire danger levels in Southern Michigan ranging from “high” to “extreme.” (Usually fire dangers become less significant after a spring “green up,” but this year was an exception due to the drought effects.) Water flows in various rivers and creeks were far below normal—in many cases only about 60% of their usual rates. In addition to various Red Flag Warnings, by mid-August the Michigan Department of Natural Resources released a proclamation prohibiting the use of fire on or adjacent to forest lands for 75 counties in Michigan. In late August, drought conditions worsened, with 23 Northern Michigan counties at moderate (D1) drought status and two (Chippewa and Mackinac) at severe (D2) drought status. Although some rainfall in early September allowed the fire restriction proclamation to be rescinded in 23 southern Michigan counties, it remained in effect for 52 of the more northern counties. By late September, drought conditions had been alleviated somewhat by additional rainfall, except for the Upper Peninsula, which still had severe drought (D2) status in seven of its western counties, and moderate (D1) drought status for 5 of its eastern counties. (Source: Law Enforcement Information Network messages)

In the United States, drought conditions often exist in some region of the country, with some area likely to be experiencing drought conditions at a particular time. This does not mean that Michigan is also experiencing a dry spell at the same time.

Drought can be a "low-profile" hazard that does not get a lot of public attention in Michigan, compared with the Rocky Mountain or Great Plains states. Nevertheless, parts of Michigan have tended to experience significant drought conditions an average of about 20% of the time (depending upon how this is measured). Even if the occurrence of drought appears at first to be of lesser concern for a community, it is important to include a consideration of the drought hazard in local hazard mitigation planning, since plans are an excellent way to deal with gradual or longer-term hazards such as drought.

When a drought takes place, there are many impacts that can result from the extended dry period. These impacts can be classified as economic, social, and/or environmental. Of great significance is the economic loss of crop production through lower yields, poorer crop quality, and reduced productivity of the land. (Michigan's fruit production is especially vulnerable to lesser yields, as was seen in a 2001 drought event that caused the destruction of one-third of the state's fruit and vegetable crop.) Timber production is also reduced through possible forest fires/tree diseases, and fisheries also have lesser amounts of fish. Lessened production in the agricultural sector leads to income losses for farmers and industries dependent on agricultural products. Lower hydrologic levels lead to water shortages for municipalities and possible shutdowns of industries and businesses that depend on large volumes of water. The quality of water tends to diminish with lower water levels, as well. Tourism becomes hampered by lower lake and river depths, due to the recreational difficulties and inconveniences that are caused. Severe and prolonged droughts could have catastrophic effects on the economy, in cases when adverse conditions lead to disruptions in the regional and national economy and when widespread economic losses affect the supply and distribution of goods and services.

Droughts can come to threaten to public health and safety, as water shortages and decreased water quality raise threats of illness, land subsidence, and wildfires. Conflicts between water users can arise, especially when a river or lake has competing uses among municipal, agricultural, industrial, and recreational users. Water restrictions and limitations among residents can also change daily lifestyle patterns and create social unrest in severe cases. Water is frequently needed for emergency responses to fires, either those in structures or wildfires in natural areas.

Environmentally, a drought brings the aforementioned lowering of water levels and water quality for surface lakes and rivers, and strains the subterranean aquifers in the state. Various animal and plant populations decline and are at heightened risk of disease. Air quality is reduced by an increase of dust and pollutants in the air. Soil quality and quantity is also diminished due to enhanced erosion, especially around freshly exposed areas near lowered lakes and streams.

The process of drought monitoring involves having ready access to an ongoing supply of information regarding precipitation, stream flows, lake levels, etc. By examining one or more drought indices, encroaching or existent drought conditions can be monitored and adapted to. Drought-related scales include river and stream flows (expressed either as a percentage of normal or as a percentile), the Standardized Precipitation Index, Crop Moisture Index, Surface Water Supply Index, and the Drought Monitor. This type of information may be found through the USGS Drought Watch web page at http://waterwatch.usgs.gov/?m=dryw&r=mi. Through these, an assessment of present conditions and forecasts are at your fingertips. Using the indicators given by these agencies, you can determine how close or how severe drought conditions may be for your area. Depending on the readings and predictions from the indices, you can determine how much risk and what kind of potential losses may arise from year to year. Heading into springtime in a given year with above average precipitation lessens the threat of impending drought (and its consequences) while dry fall and winter conditions lead to a heightened awareness of potential summer drought conditions.

Urbanized Areas

The entire state is subject to the impacts of drought. However, some areas are more vulnerable to certain drought-related impacts than others. Large urbanized areas can be more vulnerable to water shortages and business disruptions due to the sheer number of water users that are competing for the limited water resources. In those areas, water management strategies typically have to be implemented to deal with the water shortage problems. Public health and safety concerns are also numerous - everything from maintaining adequate water supply for firefighting to addressing the needs of the elderly, children, ill or impoverished individuals suffering from heat-related stress and illness. The

latter is particularly problematic for densely urbanized, inner-city areas, because heat-related deaths occur much more frequently in those areas than in suburban and rural areas. (See the Extreme Temperatures section for more detailed information.)

Rural Areas

In rural agricultural areas and the heavily forested areas of Northern Michigan, drought brings on a host of other problems to address. The agricultural areas of southern Lower Michigan are highly vulnerable to drought conditions that impact the quantity or quality of crops, livestock, and other agricultural activities. These areas often depend heavily on agricultural production for their economic needs. A prolonged drought can seriously impact local and regional income, which in turn has a rippling effect on the other components of the economy. Drought can also cause long-term problems that can negatively affect the very viability of some agricultural operations.

In Northern Michigan's forested regions, drought can adversely impact timber production and some tourism and recreational enterprises. This can also cause a drop in income, which impacts other economic sectors. The biggest problem drought presents, however, is the increased threat of wildfire. Many Northern Michigan counties are heavily forested and are therefore highly vulnerable to drought-related wildfire threats. As the 1976 Seney fire proved, a drought-impacted landscape could quickly turn a small fire into a raging, out of control conflagration.

Statewide

Tourism is an important source of revenue for Michigan. The Great Lakes attract numerous boaters and vacationers each year. Many of the "nice weather" activities and attractions involve water-related swimming, boating, fishing, and resort activities, and these forms of recreational and tourist attractions can all be negatively impacted by the effects of drought conditions. Resort areas and boat docks have physical designs that tend to be based on particular water levels. In recent cases of moderate and severe drought, as described above, stream flows can fall below 50% of their normal levels, in many cases reducing the navigability of waterways and altering the relationship between water levels/locations and built facilities for recreational access to that water (boardwalks, docks, fishing sites, et cetera).

Drought Contingency Planning

Because of variations in the drought threat throughout the state, local communities should develop and maintain drought contingency plans (as part of their overall emergency preparedness effort) that address the primary threats that drought presents in their area. For urban jurisdictions, that threat is primarily related to water supply and use management, heat-related illnesses, and continuation of industrial and business operations. For rural jurisdictions, that threat is primarily agricultural and wildfire-related. Such preparedness efforts will not eliminate the negative effects of drought, but they can at least help minimize and manage the consequences of those effects on the population.

Because drought is a low-profile hazard, it does not receive as much attention as it probably should from the emergency management community, governmental agencies, or the public in general. As a result, drought contingency planning is typically a lower priority activity than is planning for other types of natural hazards. Because of the lack of pre-planning, historic responses to drought have been ad hoc and typically involve the creation of special task forces or interagency groups to address drought-related issues as they arise. Once the crisis is over, little is typically done in terms of time or resource commitment in order to ease the impacts of the next drought. Part of the problem stems from the fact that drought contingency planning faces many obstacles, including: 1) lack of a single definition of drought that works in all regions of the country; 2) lack of unified, consistent policies on natural resource management (including water) among states and regions in the U.S.; 3) lack of a lead, coordinating agency for drought mitigation and planning; 4) lack of "dramatic," high-profile impacts (i.e., property damage, casualties, debris, etc.) – which lessens the severity of drought in the minds of community decision-makers and the public; 5) the infrequent nature of drought makes it difficult to garner support for planning and mitigation actions; and 6) the widely-held perception that, because the problem is so enormous in scope and magnitude, there is little that can be done to prevent drought or lessen its impacts.

Having a Drought Contingency Plan for a community is quite important in the event that a severe drought impacts your area. Such a plan should be a separate document detailing what steps need to be taken in the event of a drought. The plan should cover the following questions:

1) Where are primary water sources for the general population?
2) Where are alternative sources for water if the primary sources are inadequate for the community's needs?

3) At what point of lessening water resources do local water restrictions go into place?
4) Are there incrementally strict water regulations related to drought severity?
5) At what point do water restrictions cease?
6) What are the costs of bringing outside water into the community?
7) What is the hierarchy of water distribution to residential, commercial, agricultural and industrial areas?
8) How will children, the elderly, the ill, and other vulnerable citizens be accounted for?

One thing is certain when it comes to drought. As the population increases (both in the U.S. and worldwide), so too does the need for water for drinking, growing food, and running businesses and homes. That increasing need greatly heightens vulnerability to future droughts.

Climate Change Considerations

Although the effect of climate change on Michigan has been an overall increase in precipitation, and the severity of droughts has generally been decreasing over the past half-century, nevertheless there will still be drought events and dryer seasonal phases, especially in areas that are locally more susceptible. With sufficient planning and water infrastructure, the climate change effects upon this hazard may actually be beneficial on the whole, although the hazard will not disappear anytime soon.

Impact on the Public

Drought impacts may include limited or restricted access to water, and higher prices for water and agricultural goods. There is a threat to public health and safety, as water shortages and decreased water quality raise threats of illness, land subsidence, and wildfires. Conflicts between water users can arise, especially when a river or lake has competing uses among municipal, agricultural, industrial, and recreational users. Water restrictions and limitations among residents can also change daily lifestyle patterns and create social unrest in severe cases. There is also the possibility of a substantial economic impact on an area's agricultural sector, and that sector is very important for many of Michigan's rural areas, both in terms of the local area's economics (export value) as well as its employment (proportion of the labor force). Drought may also cause erosion of topsoil (with an associated loss of productivity and land value) and exacerbate other types of erosion, involving associated costs for property owners.

Impact on Public Confidence in State Governance

In some areas, the government is responsible for infrastructure maintenance and water supply planning and storage, and could be perceived as having failed during a major drought event. Actual responsibility for these issues varies with the specific jurisdiction(s) and agencies involved. Public expectations of government responsibility may be lower in areas with many natural water sources, and areas that make heavy use of individual rather than municipal supply sources. Some interesting cases emerge, however, in areas that have industries that commercially bottle area groundwater for profit. In cases of drought, or of lessened quantity or quality of local groundwater, there is likely to be popular discontent among segments of the public who hold local or state government responsible for "allowing" (or even "favoring") for-profit water bottling businesses to compete with the claimed interests of the area's residential water-users.

Impact on Responders

Droughts may be expected to affect a community's capacity to fight wildfires, and perhaps even major structural fires as well. There may be access issues involving egress into private property. For example, a water shortage may require access to a water pond on private property, to assist with efforts to fight a wildfire in the area. Otherwise, no particular responder issues should arise from a drought event.

Impact on the Environment

A drought can have serious consequences for the environment if the length and severity of the event is great enough. The hydrological effects of drought can include a loss of wetlands, and lower water levels in lakes, ponds and rivers that are used for irrigating agricultural crops. Additionally, a deficit in rain for an extended period of time may cause ground water depletion and a reduction in the water quality. Drought may also impact plant and animal life by a reduction in drinking water and loss of biodiversity. Drought is also the cause of many wildfires, which destroy wildlife habitats and alter an area's ecosystem. Air quality is reduced by an increase of dust and pollutants in the air. Soil quality and quantity is also diminished due to enhanced erosion, especially around freshly exposed areas near lowered lakes and streams.

Drought Related Monitoring and Measurement

The process of drought monitoring involves having ready access to an ongoing supply of information regarding precipitation, stream flows, lake levels, etc. By examining one or more drought indices, encroaching or existent drought conditions can be monitored and adapted to. Drought-related scales include river and stream flows (expressed either as a percentage of normal or as a percentile), the Standardized Precipitation Index, Crop Moisture Index, Surface Water Supply Index, and the Drought Monitor. This type of information may be found through the National Drought Mitigation Center website, http://www.drought.unl.edu/index.htm, or the USGS Drought Watch web page at http://waterwatch.usgs.gov/?m=dryw&r=mi. Through these, an assessment of present conditions and forecasts are at your fingertips. Using the indicators given by these agencies, you can determine how close or how severe drought conditions may be for your area. Depending on the readings and predictions from the indices, you can determine how much risk and what kind of potential losses may arise from year to year. Heading into springtime in a given year with above average precipitation lessens the threat of impending drought (and its consequences) while dry fall and winter conditions lead to a heightened awareness of potential summer drought conditions.

Significant U.S. Droughts: 1900-present

Drought Years	U.S. Location(s) Primarily Affected
1924-1934	California
1930-1940	Midwest ("Dust Bowl" drought)
1942-1956	Southwest
1952-1956	Mid-continent and Southeast
1961-1967	Northeast
1976-1977	Great Plains, Upper Midwest, West
1980-1981	Central, Eastern
1987-1989	Central, Eastern
1987-1992	California, Upper Great Plains
1998-1999	Northeast, Mid-Atlantic
2000-2001	South-Central, Southeast, Michigan / Ohio
2002-2003	Western, Central Midwest, Eastern

Source: Multi-Hazard Identification and Risk Assessment, FEMA, 1997; National Drought Mitigation Center; National Oceanic and Atmospheric Administration; MSNBC; USA Today

Of these historic national event periods, several were of particular significance to Michigan. After some explanation of Michigan's 10 climate divisions, which have been used for drought monitoring by the National Climatic Data Center, more extensive detail will be provided about the most notable historic drought events, in terms of their effects on Michigan.

Michigan's 10 climate divisions (for drought monitoring and analysis)

Information from the National Climatic Data Center is available for the current tracking and historical research of drought events in Michigan, but since dry conditions in one region may be balanced (in a statewide average) by wet conditions in another region, it is necessary to look at specific regions rather than the state as a whole, to assess the presence and severity of drought conditions from the historical data. For this plan, 126 years of data was analyzed (since 1895) for each of the 10 climate divisions illustrated in the map at left.

To assist with local planning efforts, the counties contained within these 10 climate divisions are hereby listed, and although historical data can at this time only be provided for the divisions as a whole, a summary of the most severe events from NCDC records have been included for each of the ten Climate Divisions. Following this is an overarching description of incidents and trends shown in historical drought records for Michigan.

Significant Droughts affecting Michigan

Division 1: Baraga, Dickinson, Gogebic, Houghton, Iron, Keweenaw, Marquette, Menominee, and Ontonagon Counties. The most extreme drought was in January 1977, when the Palmer index hit a record low of -6.67. Lengthy drought incidents took place in 1895-1896 (9 months), 1898-1899 (8 months), 1910-1911 (19 months), 1930-1931 (16 months), 1933-1934 (9 months), 1943-1944 (8 months), 1947-1949 (23 months), 1957-1958 (16 months), 1963-1964 (14 months), 1976-1977 (14 months), 1986-1987 (12 months), 1989-1990 (13 months), and 2006-2007 (16 months).

Division 2: Alger, Chippewa, Delta, Luce, Mackinac, and Schoolcraft Counties. The most extreme drought was in January 1931, when the Palmer index hit a record low of -7.18. Lengthy drought incidents took place in 1895-1896 (15 months), 1898-1899 (8 months), 1909-1911 (26 months), 1919-1920 (8 months), 1920-1922 (17 months), 1925-1926 (14 months), 1929-1931 (26 months), 1947-1949 (20 months), 1955-1956 (14 months), 1962-1964 (21 months), 1976-1977 (8 months), 1987 (8 months), 1989-1990 (9 months), 1997-1999 (21 months), 2000-2001 (14 months), and 2005-2007 (22 months).

Division 3: Antrim, Benzie, Charlevoix, Emmet, Grand Traverse, Kalkaska, Leelanau, Manistee, Missaukee, and Wexford Counties. The most extreme drought was in January 1931, when the Palmer index hit a record low of -8.07. Lengthy drought incidents took place in 1895-1896 (17 months), 1898-1899 (8 months), 1899-1901 (21 months), 1901-1902 (15 months), 1908-1911 (37 months), 1913-1914 (11 months), 1914-1915 (10 months), 1919-1920 (8 months), 1920-1922 (17 months), 1925-1926 (17 months), 1929-1931 (28 months), 1935-1936 (20 months), 1955-1956 (13 months), and 1976-1977 (13 months).

Division 4: Alcona, Alpena, Cheboygan, Crawford, Iosco, Montmorency, Ogemaw, Oscoda, Otsego, Presque Isle, and Roscommon Counties. The most extreme drought was in February 1931, when the Palmer index hit a record low of -8.51 (the all-time record for Michigan). Lengthy drought incidents took place in 1895-1896 (17 months), 1898-1899 (8 months), 1899-1902 (37 months), 1909-1911 (28 months), 1913-1915 (26 months), 1919-1922 (33 months), 1924-1926 (19 months), 1929-1931 (28 months), 1948-1949 (9 months), 1955-1956 (12 months), 1963-1964 (11 months), 1976-1977 (13 months), 1981-1982 (12 months), 1989-1990 (8 months), and 1999-2000 (9 months).

Division 5: Lake, Mason, Muskegon, Newaygo, and Oceana Counties. The most extreme drought was in January 1931, when the Palmer drought severity index hit a record low of -7.20. Lengthy drought incidents took place in 1895-1896 (15 months), 1899-1900 (11 months), 1901-1902 (10 months), 1909-1911 (24 months), 1925-1926 (11 months), 1930-1931 (18 months), 1956-1957 (8 months), 1962-1963 (9 months), 1964-1965 (9 months), 1971-1972 (12 months), 1976-1977 (13 months), and 2002-2003 (12 months).

Division 6: Clare, Gladwin, Gratiot, Isabella, Mecosta, Midland, Montcalm, and Osceola Counties. The most extreme drought was in February 1931, when the Palmer index hit a record low of -7.56. Lengthy drought incidents took place in 1895-1896 (15 months), 1899-1900 (13 months), 1900-1902 (20 months), 1910-1911 (19 months), 1913-1915 (23 months), 1919-1922 (30 months), 1924-1926 (16 months), 1930-1932 (25 months), 1934-1935 (10 months), 1936-1937 (13 months), 1944-1945 (8 months), 1963-1964 (10 months), 1971-1972 (12 months), and 1976-1977 (14 months).

Division 7: Arenac, Bay, Huron, Saginaw, Sanilac, and Tuscola Counties. The most extreme drought was in February 1931, when the Palmer index hit a record low of -7.57. Lengthy drought incidents took place in 1895-1896 (15 months), 1899-1900 (13 months), 1900-1902 (20 months), 1909-1912 (33 months), 1913-1915 (24 months), 1919-1922 (32 months), 1924-1926 (17 months), 1930-1932 (28 months), 1934-1935 (16 months), 1936-1937 (14 months), 1938-1939 (8 months), 1939-1940 (13 months), 1946-1947 (8 months), 1963-1965 (18 months), 1971-1972 (9 months), 1976-1977 (8 months), and 1998-1999 (12 months).

Division 8: Allegan, Berrien, Cass, Kalamazoo, Kent, Ottawa, and Van Buren Counties. The most extreme drought was in February 1931, when the Palmer index hit a record low of -6.57. Lengthy drought incidents took place in 1895-1896 (8 months), 1901-1902 (10 months), 1914-1915 (8 months), 1925-1926 (11 months), 1930-1932 (29 months), 1934-1935 (9 months), 1946-1947 (9 months), 1953-1954 (8 months), 1956-1957 (9 months), 1962-1964 (31 months), 1999-2000 (10 months), and 2005-2006 (10 months).

Division 9: Barry, Branch, Calhoun, Clinton, Eaton, Hillsdale, Ingham, Ionia, Jackson, Shiawassee, and St. Joseph Counties. The most extreme drought was in April 1931, when the Palmer index hit a record low of -6.82. Lengthy drought incidents took place in 1895-1896 (13 months), 1899-1900 (11 months), 1901-1902 (14 months), 1913-1914 (9 months), 1914-1915 (10 months), 1924-1926 (15 months), 1930-1932 (22 months), 1934-1935 (12 months), 1946-1947 (8 months), 1953-1954 (11 months), 1962-1965 (30 months), and 2002-2003 (8 months).

Division 10: Genesee, Lapeer, Lenawee, Livingston, Macomb, Monroe, Oakland, St. Clair, Washtenaw, and Wayne Counties. The most extreme drought was in March 1931, when the Palmer index hit a record low of -6.82. Lengthy drought incidents took place in 1895-1896 (8 months), 1900-1902 (24 months), 1913-1914 (12 months), 1914-1915 (12 months), 1925-1926 (13 months), 1930-1932 (24 months), 1933-1937 (42 months), 1939-1940 (12 months), 1952-1953 (8 months), 1953-1954 (17 months), 1963-1965 (35 months), 1971-1972 (15 months), and 1998-1999 (9 months).

The following two tables summarize 116 years of drought records in all 10 of Michigan's specified climate divisions. There are many possible ways of expressing this data and comparing Michigan's geographic areas. A consideration of the most severe Palmer drought index values has already been provided (which found that division number 4 had the most severe drought in Michigan, with a Palmer index of -8.51 for February of 1931), along with lists of lengthy drought periods (which numbered from 12 to 17 per division, during the period from 1895 to 2010). The first table below expresses the percentage of years that either had no drought months at all (with the Palmer Index always above a value of -2.0), or had drought months beyond a certain level of severity. Since a Palmer Index of -2.0 is considered to be a moderate drought (U.S. Drought Monitor category D1), this was the base criterion used to establish the presence of drought in the area during a given month. The percentage of years in which Palmer Index values fell below various cutpoints for drought severity are provided in the table. The annual figures suggest that climate division 4 is the most drought-prone within Michigan.

Drought Years in Michigan, by Climate Division
(covering the 116 years from 1895 to 2010)

Climate Division	Years without any drought months	With drought ≤ - 2.0 Palmer	With drought ≤ - 3.0 Palmer	With drought ≤ - 4.0 Palmer	With drought ≤ - 5.0 Palmer	With drought ≤ - 6.0 Palmer	With drought ≤ - 7.0 Palmer
1	50%	50%	28%	13%	9%	2%	0
2	41%	59%	39%	21%	**10%**	2%	1%
3	40%	60%	35%	20%	9%	2%	**2%**
4	**37%**	**63%**	39%	**23%**	**10%**	**3%**	**2%**
5	43%	57%	29%	12%	2%	2%	1%
6	39%	61%	31%	18%	3%	2%	**2%**
7	38%	62%	**40%**	20%	4%	2%	1%
8	44%	56%	30%	9%	2%	1%	0
9	43%	57%	29%	16%	4%	1%	0
10	46%	54%	34%	20%	6%	**3%**	0

An analysis by year tends to overstate Michigan's drought-susceptibility, because the presence of a single drought month may be counted the same as an entire year of sustained drought (although longer drought periods often will be distinguished by having more severe Palmer Index values). A single month's drought will not necessarily cause severe agricultural impacts, because the timing of the drought with regard to the crop cycle is also important for the extent of drought impact. Therefore, an analysis of the percentage of drought months is also provided here, as a different indicator of drought frequency. This table also suggests that Climate Division 4 is the most drought-prone area in Michigan. The listing (on the previous page) of lengthy drought incidents (lasting 8 months or longer) can also give a kind of indicator regarding the frequency of droughts that likely had a significant agricultural impact, although these are all summary indicators by climate division and may vary considerably from the actual performance of individual farms within a particular area. The differences between Michigan's climate divisions may be significant, but are not enormous. One reason for this is that drought is defined with respect to an area's precipitation norms. It may be noteworthy that Climate Division 4 was also the location of Michigan's highest and lowest recorded temperature extremes.

Drought Months in Michigan, by Climate Division
(covering the 1,392 months from January 1895 to December 2010)

Climate Division	Months without any drought (Palmer >-2)	With drought ≤ - 2.0 Palmer	With drought ≤ - 3.0 Palmer	With drought ≤ - 4.0 Palmer	With drought ≤ - 5.0 Palmer	With drought ≤ - 6.0 Palmer	With drought ≤ - 7.0 Palmer
1	79.1%	20.8%	9.4%	3.8%	1.3%	0.2%	0
2	73.3%	26.7%	13.7%	4.7%	1.5%	0.3%	0.1%
3	71.9%	28.1%	12.1%	5.2%	1.7%	0.7%	**0.4%**
4	**69.8%**	**30.2%**	**15.7%**	**6.8%**	1.9%	**0.8%**	**0.4%**
5	77.9%	22.1%	8.2%	2.5%	0.7%	0.4%	0.1%
6	73.7%	26.3%	10.8%	4.4%	1.1%	0.6%	**0.4%**
7	70.9%	29.1%	14.5%	5.6%	1.7%	0.6%	0.3%
8	79.7%	20.3%	8.0%	2.0%	0.8%	0.3%	0
9	79.2%	20.8%	8.6%	4.1%	1.3%	0.4%	0
10	75.6%	24.4%	12.1%	5.5%	**2.4%**	**0.8%**	0

1895-1896 Statewide

The available NCDC drought records (those that use the Palmer drought index) began with a period of extreme drought throughout Michigan. Every one of Michigan's climate divisions registered drought conditions for at least 8 months—some as long as 17 months—during this period. The drought was exceptionally severe in the Eastern Upper Peninsula and the Traverse Bay area. The Eastern U.P. had Palmer index values below -5 for four months in a row, between October and January. Recovery was spotty and temporary over the following few years, and it is probable that numerous areas felt little distinction between this drought event and the one that followed closely afterward.

1898-1902 Statewide

Some areas may not have even felt much of a recovery from the preceding drought event when things again took a turn for the worse as the new century arrived. Every one of Michigan's climate divisions felt lengthy droughts, and they tended to last even longer than the previous event had. The Upper Peninsula felt relatively short impacts, with no more than 8 drought months in a row, but the Lower Peninsula had an extremely rough time. Drought severity was exceptional in the Northern Lower Peninsula, reaching Palmer Index values of -5 and even less. In the four years between July of 1898 and June of 1902, the Northwestern Lower Peninsula only experienced three months that were just barely above a Palmer value of -2, the rest of the time being officially in an extended period of drought. The Northeastern Lower Peninsula fared even worse, with only 2 months registering a tiny smidgeon above the official drought level (-1.98 on the Palmer Index) while the rest of the time was disastrously dry. To the south, things were not quite as disastrous, although extreme drought levels were still reached during that period of time. Only the far southwestern tip escaped with "merely" a severe drought classification (bottoming out twice at -3.66 on the Palmer Index in 1899 and also in 1902).

1908-1912 Northern Michigan

The area north of where State Highway 57 now lies was all struck by an exceptional drought event, and in the northernmost areas of the state, conditions were exceptionally severe, with the Palmer Index reaching levels almost as low as -6 during multiple months in climate areas 1, 2, 3, and 4. The Northwestern Lower Peninsula had a particularly rough time, in that there wasn't much break for that region between this drought event and the following one, which reached an even greater level of severity. The Northeastern Lower Peninsula, after first experiencing a fairly moderate 8 months of initial drought, then sank into 37 straight months of drought conditions. In the Northwestern Lower Peninsula, the drought took the form of three periods—eight months, then 21 months, and finally 15 months in an official state of drought. Just to the south and east (the central and thumb areas of the state), 13 initial months of drought were, after an interlude, followed by 20 additional months of drought in a row.

1913-1915 Lower Peninsula

Although the Upper Peninsula had mostly recovered from the previous period of extreme drought, the Lower Peninsula had much more suffering to endure, following only a brief interlude of sporadic recovery in 1912 and 1913. Conditions were particularly extreme on the eastern side of the state, whose Palmer Index values all fell as low as -5 at certain points, or lower. The Northeastern Lower Peninsula suffered 6 straight months of such extreme drought levels, including Palmer Index values of -6.76, -6.56, -6.37, and -6.32 from December of 1913 to March of 1914.

1919-1922 Northeastern Michigan

Just after the end of World War I, as the influenza pandemic was calming, parts of Michigan still had years of gloomy drought conditions to endure. Although not reaching the exceptional severity of the previous drought event, this new period of drought was quite persistent. Climate divisions 4, 6, and 7 all experienced 30 or more continuous months of drought. Climate divisions 2 and 3 had a slightly less deleterious pattern, with 8 continuous drought months early on, followed by a lengthier period of 17 straight months of drought. In all these areas, the drought reached the extreme level (D3).

1924-1926 Statewide

All parts of Michigan were again struck with more hydrological problems in the mid-1920s, except for the Western Upper Peninsula, where hydrologic conditions were mostly reasonable. Most conditions were severe (D2), although the northern, central, and eastern Lower Peninsula (climate divisions 3, 4, 6, 7, 9, and 10) did reach extreme (D3) drought levels at certain times.

1930s Midwest / Statewide

Without a doubt, the "Dust Bowl" drought of the 1930s was the most famous drought ever to occur in the U.S. That drought, which was the subject of John Steinbeck's 1939 Pulitzer Prize winning book The Grapes of Wrath, was an ecological and human disaster of huge proportions. It was caused by misuse of the land combined with years with lack of rainfall. As the land dried up, great clouds of dust and sand, carried by the wind, covered everything and the term "Dust Bowl" was coined. As a result of this drought, millions of acres of farmland became useless, forcing hundreds of thousands of people to leave their farms and seek an existence elsewhere. (Many migrated to California, which was featured prominently in Steinbeck's book.) Although exact figures were not kept, some researchers estimate that nearly $1 billion (in 1930s dollars) was provided in assistance to victims of the Dust Bowl drought. That event also ushered in a new era or farming and conservation programs and practices aimed at preventing a recurrence of a drought of the magnitude and impact of the Dust Bowl drought.

In Michigan, this "dust bowl" period took the form of a most severe statewide drought condition from 1929 to 1932, followed by a less severe period from 1933 to 1937 in which the general pattern involved the south and western areas seeing the hardest conditions, and finally a period of limited spotty problems between 1938 and 1940.

The most extreme conditions ever seen in Michigan occurred in the period from 1929 to 1932. Nine out of Michigan's ten climatic divisions (the Western U.P. being the only exception) set their all-time drought records during the beginning of 1931, with Palmer Drought Index values varying from -6.57 (the southwestern tip of the Lower Peninsula) to the all-time Michigan record of -8.51 (in the Northeastern Lower Peninsula). Even if only the most exceptional drought levels (D4) are considered, these conditions were unusually long-lasting. Between 1930 and 1931, all nine of Michigan's most heavily affected climate divisions experienced this most unusual level of drought for at least 6 straight months (in climate division 2) to as many as 15 continuous months (in climate division 7). Unfortunately, those areas that experienced the more prolonged conditions of extreme drought were also the most heavily agricultural areas of the state, in the southern Lower Peninsula. Nevertheless, the entire state was struck very hard—the Western Upper Peninsula had 16 straight months of drought, and most other areas had two straight years or longer in drought conditions (climate area 8 had 29 consecutive months of drought between July 1930 and November of 1932).

The mid-1930s saw the drought conditions markedly reduced in climate divisions 2, 4, and 5, although the other areas of the state were still plagued with a level of problems that still compare with practically any other drought period in Michigan. Although not extreme in the northern areas of the state, the drought was still severe during a significant portion of this time frame. Parts of the southern Lower Peninsula, however, did experience conditions that were extreme and even exceptional. Climate division 7 saw five straight months in the most extreme D4 level of drought, between November 1936 and March 1937. Climate division 10 exceeded this, with ten straight months of D4 drought, including Palmer Drought Index values of -6.05 and -6.03 in December and January of 1934-1935. During this period, the southeastern Michigan region at this time set an all-time state record for the longest number of consecutive months under drought conditions—the 42 months between August 1933 and January 1937. By 1938, the Thumb area was the only part of Michigan still experiencing serious long-term drought problems. Although the area had some months of relief in early 1938, drought conditions resumed by the end of the year for a period of 8 consecutive months, and then between 1939 and 1940, another 13 month period of drought followed. During that latter period, southeastern Michigan shared in the drought conditions for a full year, and these two regions did reach the extreme D3 level of severity.

1946-1947 Part of the Lower Peninsula

Climate divisions 7, 8, and 9 all experienced about 8 continuous months of drought, peaking at the severe D2 level of intensity.

1947-1949 Far Northern Michigan

Climate divisions 1, 2, and 4 experienced lengthy drought conditions during these years. The mildest area this time was the Northeastern Lower Peninsula (9 months of drought, peaking at the extreme D3 level), while the Upper Peninsula was very heavily struck (more than 20 consecutive months of drought, peaking at the exceptional D4 level for two to three of those months).

1953-1954 Far Southern Michigan

Climate divisions 8, 9, and 10 were the focus of drought this time, with the effects worsening as one proceeded farther east. In the southwest, 8 consecutive months of drought were felt, peaking at the extreme D3 level for two months. In the southeast, this was instead felt as 17 consecutive drought months, with a D3 peak for three straight months in the middle.

1955-1956 Northeastern Michigan

Climate divisions 2, 3, and 4 all felt at least 12 consecutive drought months. Although the Eastern Upper Peninsula peaked at the extreme D3 level of severity, the Northern Lower Peninsula hit the exceptional D4 drought level—the western region staying there for four consecutive months, and the eastern region only experiencing one such month.

1956-1958 Western Michigan

By the late 1950s, the drought problem had shifted to be felt the hardest in the western Michigan climate divisions of 1, 5, and 8. The Western Upper Peninsula experienced 16 consecutive months of drought, peaking a couple of times at the severe D2 level. The Western Lower Peninsula was only struck for 8 to 9 consecutive months, but at a more intense level, with climate division 8 plunging into the extreme D3 level of drought.

1962-1965 Statewide

This was the only clear and serious statewide drought event to take place since the 1930s, which partially demonstrates a general trend of lessening drought problems in Michigan during the second half of the 20th Century when compared with the first half. Nevertheless, this was definitely the worst drought event to strike Michigan since the 1930s. In this event, only the Northwestern Lower Peninsula was significantly spared the extended and severe effects experienced throughout the rest of the state—that area's worst point was a two month spell at the severe D2 level. By contrast, the entire Southern Lower Peninsula had to endure at least 30 consecutive drought months, many of which were at the D2 level, or worse. Again, there was a pattern in which the drought was felt more intensely the farther to the east one was located. Southeastern Michigan experienced 9 consecutive months at the exceptional D4 level of drought. In the Upper Peninsula, things were also very bad—between 14 and 21 months of drought, which also peaked at the exceptional D4 level, but for a period of 4 to 5 months. The middle years of 1963-1964 were the worst phase of this event, for most parts of the state. It was mostly in the very south that 1962 was a bad year as well.

1971-1972 Part of the Lower Peninsula

Climate divisions 5, 6, 7, and 10 had to endure 9 to 12 consecutive months of drought conditions. Although division 7 (the Thumb) peaked briefly at a severe D2 drought level, the other three areas peaked for a longer period of time at the extreme D3 drought level.

1976-1977 National (including Northern Michigan)

The 1976-77 drought in the Great Plains, Upper Midwest, and West also severely impacted Northern Michigan. Climate divisions 1 through 7 all experienced drought conditions for a stretch of between 8 and 14 consecutive months. Extreme drought conditions in the Upper Peninsula also contributed heavily to the large wildfire that struck the Seney area in July of 1976, even though this was not the most severely impacted area of the state. The fire was started by a lightning strike that ignited dry grasslands and eventually burned over 74,000 acres over a 1½ month period, costing $8 million to contain. (The chapter on Wildfires contains more detailed information about this fire.) Drought had involved a significant reduction in rainfall (6-8 inches below normal) in the area, and the water table in the 95,455 acre Seney National Wildlife Refuge had dropped one foot, exposing old vegetation, peat and muck to the drying forces of the intense sunlight. Eventually, that material became a tinderbox that helped fuel the destructive fire. Fortunately, injuries and damage to improved property were minimal, although the loss of forest resources was staggering.

The drought itself reached exceptional D4 levels in climate divisions 1, 2, 3, 4, and 6—sometimes more than once or enduring for multiple months. For example, the Western Upper Peninsula saw Palmer Drought Index values of -5.92, -6.45, -6.67, and -6.11 for the four consecutive months between November of 1976 and February of 1977. In these terms of measurement, it was the hardest-hit region of the state.

Late 1980s Central U.S. (including Michigan); Eastern U.S.

First, Michigan's Upper Peninsula experienced from 8 to 12 consecutive months of drought during 1986-1987, peaking at the extreme D3 level for one month in the Western U.P, while the Eastern U.P. reached the severe D2 level. Next, a 1988 heat wave and drought impacted the Central and Eastern U.S. and caused an estimated $40 billion in damages from agricultural losses, disruption of river transportation, water supply shortages, wildfires, and related economic impacts. In response, Michigan took several steps to combat the impact of the drought on businesses, natural resources, and individual citizens. Numerous Michigan communities instituted temporary water use restrictions to ensure an adequate water supply for human consumption and other essential uses such as firefighting. To stem the potential for wildfire in Michigan, the Governor issued (in June, 1988) a statewide outdoor burning ban, which remained in effect until the end of July, 1988 (and longer in some Upper Peninsula counties). The State also formed a task force to study issues related to the drought and formulate appropriate strategies for dealing with those drought-related concerns. Fortunately, Michigan's drought conditions were not consistently severe during that summer, although they would be seen to worsen in some of the state's northern areas over the next couple of years. The final events in the chain of drought conditions took place when the Upper Peninsula again suffered a lengthy period (between 9 and 13 consecutive months) of drought between 1989 and 1990, peaking at the severe D2 level, and the Northeastern Lower Peninsula joined them in suffering 8 months in a row of drought conditions, also peaking at D2.

1998-2003 Northeast; Mid-Atlantic; South-Central; Southeast; Michigan

Droughts / heat waves in recent years have caused considerable damage to agriculture and related industries in several areas of the U.S. The summer of 1998 drought / heat wave from Texas to the Carolinas caused an estimated $6-9 billion in damage. The summer of 1999 drought / heat wave caused over $1 billion in damage – mainly to agricultural crops in the Eastern U.S. The summer of 2000 drought / heat wave in the South-Central and Southeastern U.S. resulted in over $4 billion in damages and costs. The drought / heat wave that struck Michigan during the summer of 2001 damaged or destroyed approximately one-third of the state's fruit, vegetable and field crops, resulting in a U.S. Department of Agriculture Disaster Declaration for 82 of the state's counties. In addition, the drought / heat wave caused water shortages in many areas in Southeast Michigan, forcing local officials to issue periodic water usage restrictions. In 2002, moderate to extreme drought affected more than 45 percent of the country during the months of June, July and August. Nationwide, the summer was the third hottest on record, following only 1936 and 1934. The summer of 2002 was also very hot and dry in Michigan. Several record highs were set throughout eastern Michigan during the month of September. During the first half of the month, hundreds of communities across the area were under water restrictions. Hardest hit from the drought was the agricultural industry. September yields across most of the area were estimated at under 50 percent and many counties across eastern Michigan were declared agricultural disaster areas. The severely dry weather was classified as a drought until mid 2003.

In terms of the Palmer Drought Index, the most severe problems in Michigan jumped around from year to year. The start was actually in the Eastern U.P. during 1997, with 21 drought months then following in a row until mid-1999, but resuming the next year for another 14 consecutive drought months until more than half of 2001 had passed. The extreme D3 level was reached there more than once. Meanwhile, the southeastern and thumb areas saw drought conditions sustained for 9 to 12 months between 1998 and 1999, peaking at the severe D2 level. In 1999, the areas of highest severity had shifted to the northeastern and southwestern areas of the Lower Peninsula, where 9 to 10 months of drought were sustained until 2000, and peaked at D2 in the northeast and D3 in the southwest. Finally, the adjacent western and south-central areas (climate divisions 5 and 9) became the hardest hit by the final years from 2002 to 2003, with 8 to 12 months of drought months in a row, and with peaks at D3 drought severity in the west and D2 drought severity in the central south.

2005-2007 – Northern Michigan (also Muskegon County)

The Upper Peninsula suffered from drought conditions for between 16 and 22 months starting in 2005, peaking at the exceptional D4 level in the West, and with severe D3 levels across the East. By 2007, severe drought conditions (rated D2) were noted for the Eastern Upper Peninsula and also the tip of the Northern Lower Peninsula. Specific counties named in 2007 for this level of drought included Chippewa, Mackinac, Charlevoix, and Emmet. The hay crop in the Eastern U.P. was only 50 to 70 percent of normal, and the resulting lack of feed led some farmers to downsize their cattle herds. In the northern tip of the Lower Peninsula, very high utility bills were suffered by the proprietors of farms and golf courses, due to the need for near-constant irrigation. Corn and bean crops were severely impacted. A burning ban was also issued for most of the state (the first such ban since 1998) to reduce the risk of wildfires. Significant rains in September eventually alleviated the drought.

Local reports described some effects of lower lake levels upon marine traffic in the Muskegon area. A super-freighter became stuck in the mouth of Muskegon Harbor and was reported as the second large ship to run aground within the space of a month, in the same location. Shipping officials stated that additional dredging was needed in Great Lakes ports because of low water levels. (NOTE: Although occurring at the same time as a designated drought event, this author is not certain whether this event had drought as its definitive proximate cause. Please refer to the Great Lakes Shoreline Hazards chapter for more information about varying water levels in the Great Lakes.)

May to June, 2010 – Eastern Upper Peninsula

The first five months of 2010 were quite dry, and drought conditions developed as the year progressed, culminating in a severe (D2) drought by mid-May. At first, this was considered to apply to Western Mackinac County, but the categorization would then expand to all of the Eastern Upper Peninsula until rainier conditions eased the drought. June turned out to be a wet month, fortunately causing the end of the severe drought in the area.

Drought History for Michigan Counties – arranged by region – Jan. 1996 to Oct. 2013
(The Lower Peninsula regions are ordered by "tiers" from south to north, west to east)
Please refer to the Michigan Profile Map section for an explanation of regional divisions

COUNTY or area	Drought Events	Days with Event	Tot. crop damage
Washtenaw	2	2	
Wayne	2	2	$150,000,000
.Livingston	2	2	
Oakland	2	2	
Macomb	2	2	
5 Co Metro region	**2 avg.**	**2 avg.**	**$150,000,000**
Berrien			
Cass			
St. Joseph			
Branch			
Hillsdale			
Lenawee	2	2	
Monroe	2	2	
.Van Buren			
Kalamazoo			
Calhoun			
Jackson			
.Allegan			
Barry			
Eaton			
Ingham			
.Ottawa			
Kent			
Ionia			
Clinton			
Shiawassee	2	2	
Genesee	2	2	
Lapeer	2	2	
St. Clair	2	2	
.Muskegon			
Montcalm			
Gratiot			
Saginaw			
Tuscola	2	2	
Sanilac	2	2	
.Mecosta			
Isabella			
Midland	2	2	
Bay	2	2	
Huron	2	2	
34 Co S Lower Pen	**0.6 avg.**	**0.6 avg.**	

Continued on next page…

Part 2 of Michigan County Drought Hazard History Table

.Oceana			
Newaygo			
.Mason			
Lake			
Osceola			
Clare			
Gladwin			
Arenac			
.Manistee			
Wexford	1	1	
Missaukee	1	1	
Roscommon			
Ogemaw			
Iosco			
.Benzie			
Grand Traverse	1	1	
Kalkaska	1	1	
Crawford			
Oscoda			
Alcona			
.Leelanau	1	1	
Antrim	1	1	
Otsego	1	1	
Montmorency			
Alpena			
.Charlevoix	2	2	
Emmet	2	2	
Cheboygan	2	2	
Presque Isle			
29 Co Nrthrn Lower Pen	**0.4 avg.**	**0.4 avg.**	
Gogebic			
Iron			
Ontonagon			
Houghton			
Keweenaw			
Baraga			
.Marquette			
Dickinson			
Menominee			
Delta			
Schoolcraft			
Alger			
.Luce			
Mackinac	4	4	
Chippewa	3	3	
15 Co Upp.Pen	**0.5 avg.**	**0.5 avg.**	
MICHIGAN TOTAL	**54**	**8**	**$150,000,000**

Programs and Initiatives

National Drought Policy Act and Commission

Currently, no single federal or state agency monitors drought. Rather, a number of agencies have programs and initiatives in place designed to identify, monitor, analyze, and respond to drought. Recognizing the need for a nationwide, coordinated drought policy designed to prepare for and respond to drought emergencies, Congress enacted in 1998 the National Drought Policy Act (P. L. 105-199), which established the National Drought Policy Commission. The Commission is composed of fifteen members – representative of all levels of government and other drought impacted groups – and is charged by Congress to provide advice and recommendations on the creation of an integrated, coordinated Federal policy for drought emergencies. On May 17, 2000, the Commission provided its findings and recommendations to Congress and published the report "Preparing for Drought in the 21st Century." The Report outlines a national drought policy statement developed by the Commission with preparedness as its foundation. The Report establishes five broad goals and a number of specific recommendations under each. The Commission intends to achieve the goals in the coming years through a combination of legislation, planning, coordination of programs, public / private collaborative partnerships, and public education.

Interim National Drought Council

The creation of the Interim National Drought Council (INDC) was one of the recommendations in the May 2000 report of the National Drought Policy Commission. The United States Department of Agriculture (USDA) immediately moved forward and implemented the council without congressional action. The Interim Council was created to coordinate drought services between the various levels of government until Congress authorizes and funds a permanent council. It was created through a Memorandum of Understanding (MOU) signed by the U.S. Department of Agriculture, U.S. Department of the Interior, Small Business Administration, Federal Emergency Management Agency, U.S. Department of The Army, U.S. Department of Commerce, U.S. Environmental Protection Agency, National Governors' Association, Southern Governors' Association, Western Governors' Association, National Association of Counties, U.S. Conference of Mayors, the National Emergency Management Association and representatives of urban water interests, rural water interests, the credit community, and tribes. The Consortium of Regional Climate Services, the National Association of Conservation Districts, and the National Drought Mitigation Center were added by an addendum to the MOU.

U.S. Army Corps of Engineers

The U.S. Army Corps of Engineers (USACE) Institute for Water Resources developed and maintains the National Drought Atlas, which provides information on the magnitude and frequency of minimum precipitation and stream flow in the United States (two important indices of drought). NOTE: Caution should be used when comparing streamflow statistics from the USACE spreadsheet with current, observed conditions at a particular location. This is because the statistics reflect the period of record of the data being analyzed—a longer period makes it harder for an extreme flow condition to be reflected in the value of the statistic. In some cases, it may be tricky to determine the period of time covered by the statistic, since some stations may have been inactive during certain time periods.

U.S. Geological Survey

The U.S. Geological Survey (USGS) is the primary federal agency that collects and analyzes streamflow data, another good index of the relative severity of drought. The agency provides a handy "Drought Watch" web site at http://waterwatch.usgs.gov/. The site presents a map that is continually updated through an automated analysis of USGS streamgaging stations. Additional drought-related links can be accessed from the Michigan-specific web page (http://waterwatch.usgs.gov/new/index.php?m=dryw&r=mi) by clicking on the map (or proceeding directly to the specific web page at http://mi.water.usgs.gov/midroughtwatch.php).

Another available resource for historical data (usually the period from 1933 to 1988) is the USGS Hydro-Climatic Data Network, which is composed of 1,659 streamflow stations that have 20 years or more of streamflow records. These stations are present in all 50 states and U.S. territories. The USGS, in cooperation with over 600 other government agencies, operates some 7,300 stream gauges for data collection. In addition to streamflow data, the USGS collects data on water quality, reservoir levels and contents, and groundwater levels for each state. For Michigan up to the 2005 water year, this data was being published annually in a Water Resources Data for Michigan document. Since the annual report ceased publication, official annual summaries can be obtained on-line, on a site-by-

site basis. These data can be accessed by visiting the Annual Water Data Reports site at http://wdr.water.usgs.gov/ or by visiting the web page for a specific stream gauge through http://waterdata.usgs.gov/mi/nwis/rt. The .pdf files present at these sites contain annual information about that stream location, including average daily flow rates that can be used to identify low and high water flow periods.

National Weather Service

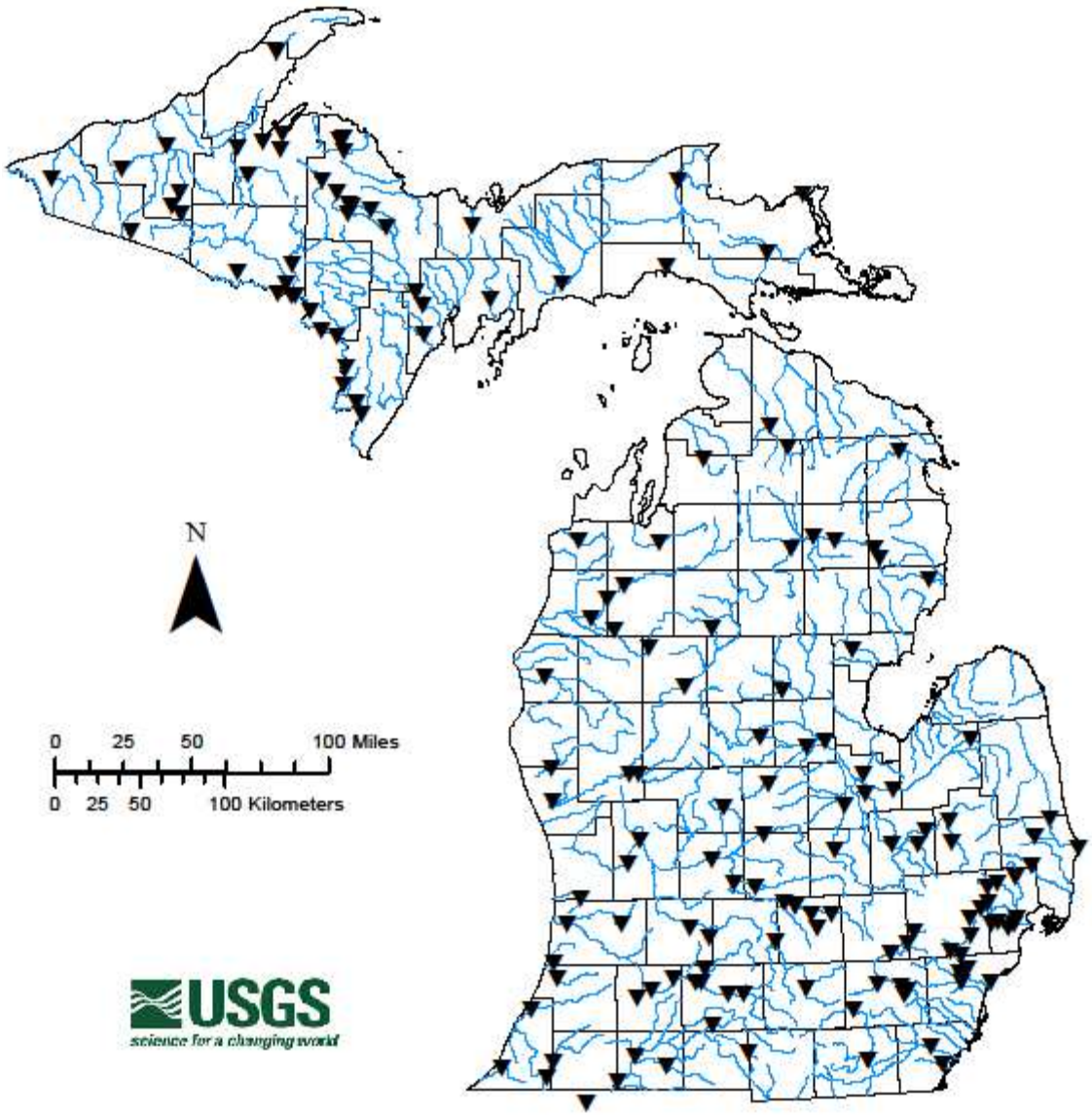
The National Weather Service (NWS) is the primary Federal agency that collects and publishes precipitation data. The NWS publishes precipitation data from approximately 9,100 non-recording and 2,100 recording stations in the United States. This data is published monthly in reports for each state, titled Climatological Data and Hourly Precipitation Data. Departure from normal precipitation is a commonly used index to determine drought severity.

U.S. Department of Agriculture

The U.S. Department of Agriculture (USDA) has a variety of programs designed to provide assistance to farmers and other agricultural enterprises adversely impacted by natural disasters – including drought. The USDA Farm Service Agency (FSA) can provide emergency loans to farmers, ranchers, and agriculture operators who have suffered property loss or economic injury. Emergency loans are made to qualified applicants in those counties designated by FEMA as eligible for Federal disaster assistance under a Presidential disaster declaration, or those that have been specifically designated in a Secretary of Agriculture disaster declaration. Eligible applicants in counties contiguous to declared or designated counties may also qualify. The USDA Natural Resources Conservation Service (NRCS) can provide technical and financial assistance to farmers and agriculture operators for land and water conservation-related efforts aimed at recovering from the adverse impacts of drought and other natural disasters.

National Drought Mitigation Center

The National Drought Mitigation Center (NDMC), located at the University of Nebraska-Lincoln, is a major research and information center whose mission is to help people and institutions in the United States develop and implement measures to reduce societal vulnerability to drought. The NDMC, through its various programs and initiatives, stresses prevention and risk management rather than crisis management. The NDMC builds on the work of the International Drought Information Center (IDIC), also at the University of Nebraska-Lincoln, which takes a worldwide perspective in its research and mitigation work related to the hazard of drought. The NDMC and IDIC are both essentially clearinghouses for drought-related research studies, policy and planning assistance, training and educational initiatives, and information sharing. They are the central coordinating points, worldwide, for drought-related programs and initiatives.



USGS Stream Gauge Locations in Michigan

State of Michigan

In Michigan, drought identification and monitoring is a multi-agency, collaborative effort that may involve the Departments of Agriculture and Rural Development, Environmental Quality, Natural Resources, Community Health, and the State Police Emergency Management and Homeland Security Division. When a drought occurs in Michigan, other agencies, such as the Office of Services to the Aging and the Department of Human Services, may also become involved to monitor the impact of the drought conditions on individuals and families. Depending on the nature and extent of the situation, a state-level task force may be set up to promote cooperation, coordination, and good information flow among participating agencies. In extreme cases, the State Emergency Operations Center may be activated and staffed for the duration of the event.

New laws came into effect on February 28, 2006 to help Michigan better manage water withdrawals to ensure adequate supplies for aquatic life and other users. These laws amended Parts 327 and 328 of the Natural Resources and Environmental Protection Act and the Safe Drinking Water Act. NOTE: This is primarily directed toward ecosystem integrity, and the low-flow conditions considered in these laws are merely representative of low-flow summer months, rather than actual drought conditions.

Mitigation Alternatives for the Drought Hazard

- Storage of water for use in drought events (especially for human needs during periods of extreme temperatures, and for responding to structural fire and wildfire events).
- Legislative acts, local ordinances, and other measures to prioritize or control water use.
- Encouragement of water-saving measures by consumers (including landscaping, irrigation, farming, and low-priority lawn maintenance and non-essential auto washing).
- Anticipation of potential drought conditions, and the preparation of drought contingency plans.
- Designs, for recreational and other water-related structures and land uses, that take into account the full range of water levels (of lakes, streams, and groundwater).
- Designs and plans for water delivery systems that include a consideration of drought events.
- Obtaining agricultural insurance.

Tie-in with Local Hazard Mitigation Planning

Because many means of implementing mitigation actions occur through local activities, this updated MHMP places additional emphasis on the coordination of State-level planning and initiatives with those taking place at the local level. This takes two forms:

1. The provision of guidance, encouragement, and incentives to local governments by the State, to promote local plan development (including a consideration of drought conditions), and
2. The consideration of information contained in local hazard mitigation plans when developing State plans and mitigation priorities.

Regarding the first type of State-local planning coordination, MSP guidance has included the "Local Hazard Mitigation Planning Workbook" (EMD-PUB 207), which is currently being updated for release by 2015. For the second type of State-local planning coordination, a section later in this plan summarizes hazard priority information as it has been reported in local hazard mitigation plans. Here, it will merely be noted that drought was identified as one of the most significant hazards in local hazard mitigation plans for the counties of Antrim and Monroe.

C. Ecological Hazards

The following outline summarizes the significant ecological hazards covered in this section:

1. Wildfires
2. Invasive species

These types of natural hazards deal with biological ecosystems, and their effects upon the human economy and built environment. The most well-known hazard of this type is that of major wildfires. Although wildfires, like floods, occur naturally, dangers exist because humans live in areas where the disaster event will periodically take place and cause damage and threats to human health and life. Ecological hazards must also be dealt with to maintain Michigan's environmental and recreational quality of life, as well as the important economic sectors that are closely connected with them (such as tourism, recreation, agriculture, and natural resource extraction).

Wildfires

An uncontrolled fire in grasslands, brushlands or forested areas.

Hazard Description

Forests cover approximately 49% (18.2 million acres) of Michigan's total land area. These vast forests provide Michigan with the largest state-owned forest system in the United States. In addition, Michigan has the fifth largest quantity of timberland acreage, with 4.2 million acres of softwoods and 13.1 million acres of hardwoods. That vast forest cover is a boon for both industry and recreation. However, it also makes many areas of Michigan highly vulnerable to wildfires.

Hazard Analysis

Although Michigan's landscape has been shaped by wildfire, the nature and scope of the wildfire threat has changed. Michigan's landscape has changed substantially over the last several decades due to wildland development, and so the potential danger from wildfires has become more severe. Increased development in and around rural areas (more than a 60% increase in the number of rural homes since the 1980s) has increased the potential for loss of life and property from wildfires. (The map at the end of this section shows the wildland / urban interface areas of highest concern in Michigan.) There are simply not enough fire suppression forces available in rural areas to protect every structure from a disastrous wildfire.

Contrary to popular belief, lightning strikes are **not** the primary cause of wildfires in Michigan. Recently, only about 7% of all wildfires in Michigan were caused by lightning strikes, and most other causes have been attributed to human activity. Outdoor debris burning is the leading cause of wildfires in Michigan. Most Michigan wildfires occur close to where people live and recreate, which puts both people and property at risk. The immediate danger from wildfires is the destruction of property, timber, wildlife, and injury or loss of life to persons who live in the affected area or who are using recreational facilities in the area.

According to 2011 MDNR information, the leading causes of wildfires from 2001 to 2010 were:

1. Debris burning (32%)
2. Equipment (17%)
3. Miscellaneous (11%)
4. Unknown (10%)
5. Campfires (9%)
6. Lightning (7%)
7. Incendiary activity (5%)
8. Children (5%)
9. Railroads (3%)
10. Smoking (3%)

<u>Areas of Greatest Vulnerability</u>

The maps and tables at the end of this section show a breakdown of wildfires by county for the period since 1981, including both the number of fires and the number of acres burned. The maps indicate that the wildfire threat in Michigan is fairly widespread geographically. The large number of permanent and seasonal homes (especially in the northern Lower Peninsula), coupled with the increase in tourists during the most dry (and therefore most vulnerable) times of the year, greatly increase the risk from wildfires.

It should be noted that the figures shown on the maps do not include those wildfires suppressed by local volunteer fire departments or the U.S. Forest Service. If those records were readily available and broken down by county, the statistics would be significantly affected. For example, the 1976 Seney fire burned approximately 74,000 acres, which included federal, state and private lands. In addition, the statistics fail to show a major wildfire problem in the southern Lower Peninsula due to the small MDNR fire force presence in that area of the state. However, local fire departments in the southern Lower Peninsula respond to hundreds of wildfires per year, and are instrumental in keeping the wildfire threat in the southern Michigan counties in check.

In geographic terms, the percentage of forested land cover is the highest (more than 75% of the total land area) across the entire Upper Peninsula and in the Lower Peninsula counties of Cheboygan, Crawford, Kalkaska, Lake, Montmorency, Oscoda, Otsego, Presque Isle, and Roscommon (based upon a 2004 inventory by the USDA). The Michigan DNR has been involved in approximately 550 wildfire events per year, in recent decades. An average of about 4 deaths per year is estimated, from major events alone.

Role of Local Governments

Local governments can take a number of actions to reduce the risk from wildfires. One important action that can be taken at the local level is to adequately address wildfire vulnerability reduction in local zoning ordinances and comprehensive/land use plans. Most local zoning ordinances lack provisions for wildfire vulnerability reduction, and most comprehensive/land use plans are not prepared far enough in advance in rural areas to adequately direct development and institute mitigation measures in high-risk fire hazard areas. Communities are not adequately utilizing land use systems that recognize special fire problems and requirements related to vegetation, topography, weather, transportation and access, water supply, and density of development.

Local fire agencies, primarily due to lack of time and/or personnel, only sporadically review proposed lot splits, subdivisions, severances and other developments for fire protection needs. In general, communities are not requiring developers to project the fire vulnerability of their large-scale developments. These projections are also not required for most variances and special use permits. Builders seeking building permits for additions to homes do not have to retrofit the existing structure to meet wildfire safety and mitigation measures. These measures could include such actions as replacing an existing roof covering with a fire-resistant or non-combustible covering, installing smoke detectors and other fire safety controls, or maintaining a “Firewise” landscape by providing adequate vehicular access, signage streets, roads and buildings, and providing adequate emergency water supplies.

Additional measures that local governments can take to reduce wildfire vulnerability include restricting open burning of trash and yard debris (which causes nearly one-third of the wildfires in the state), and developing evacuation procedures for wildfires in the jurisdiction's Emergency Operations Plan (EOP) to minimize potential injury and loss of life.

Efforts of the MDNR Forest Management Division

The MDNR Forest Management Division is committed to a multi-jurisdictional, coordinated wildfire hazard mitigation effort. The Division is actively working toward reducing the State’s vulnerability to wildfires by: 1) participating in multi-state and interagency mitigation efforts; 2) aiding local communities in developing zoning and subdivision control ordinances that adequately address wildfire mitigation; 3) regulating the days and times people are granted permits to burn debris; 4) conducting research on wildfire prevention, containment and suppression activities; and 5) developing wildfire hazard assessments to aid community and property owners in determining their vulnerability to wildfires.

The MDNR is conducting a detailed statewide assessment to determine communities’ risks from wildfire, using Geographic Information System (GIS) technology. This assessment, which is expected to take several years to complete, will identify the areas of greatest concern for wildfires based on existing and projected land uses and population concentrations, as well as topography, hydrology, soils, vegetative cover, and other natural features. The assessment will provide the MDNR and other state agencies, local governments, builders and developers, and private citizens with information needed to make “Firewise” land use / development decisions and to facilitate the creation of community wildfire protection plans (CWPP), thereby reducing the wildfire threat to people and improved property. The risk map at the end of this section was the result of an early approximation using GIS and a basic model, but current mapping will result in products of far greater validity

Despite these ongoing initiatives of the MDNR Forest Management Division, wildfire prevention must be emphasized more at the local level if a meaningful reduction in vulnerability is to occur.

Wildfire Suppression

One trend involves wildfires outstripping the ability of firefighters to suppress them. Fire protection in wildland areas cannot be provided at the same level that it is provided in urban areas. Rural fire departments tend to be volunteer forces, the members of which may be widely geographically dispersed. That dispersion greatly increases the response

time in rural and wildland areas. In addition, these forces also tend to be not as well equipped as their urban counterparts. These factors, coupled with the tremendous increases in development in wildland areas and the lack of readily available water from pressurized underground pipes, contribute to the possibility of wildfire disasters in many areas of Michigan.

Wildfire Analysis

FEMA (and others) have created fairly detailed methods for estimating wildfire risks. The information in this workbook summarizes that given in FEMA publication 386-2 ("Understanding Your Risks"). It primarily uses weather, topography, and land cover (fuel) data to estimate wildfire risks. The first activity is to map the "fuel model" categories in the community. This process currently sorts all areas into three "fuel model" categories based on the types of vegetative land covers that could act as fuels in a wildfire event. Here is a summary of the three fuel model categories described by FEMA:

LIGHT FUEL CATEGORY – Covers any of the following general descriptions of vegetation in an area:

1. Predominantly marsh grasses and/or weeds.
2. Mosses, lichens, and low shrubs are the predominant ground fuels, but have no overstory and/or occupy less than one-third of the site.
3. Grasses and/or forbs predominate. Any woody shrubs will occupy less than one-third of the site. An open overstory of conifer and/or hardwood trees may be present.
4. Brush, shrubs, tree reproduction or dwarf tree species predominate, but this is only considered light fuel if the average height of woody plants is less than 6 feet, and they occupy less than one-third of the site.
5. Deciduous broadleaf tree species predominate and the area has not been thinned or partially cut (which would create a higher-risk fuel source called "slash.")
6. Conifer species predominate, but the primary ground fuels are grasses and forbs. If the primary ground fuels are duff and litter, branch wood, and tree boles, then the area can only be considered "light fuel" if pine needles are 2 or more inches in length, the overstory is not decadent, and there is only a nominal accumulation of debris.

MEDIUM FUEL CATEGORY – Covers any of the following general descriptions of vegetation in an area:

1. Mosses, lichens, and low shrubs are the predominant ground fuels, and an overstory of conifers occupies more than one-third of the site.
2. Grasses and/or forbs predominate, with woody shrubs occupying between one-third and two-thirds of the site.
3. Brush, shrubs, tree reproduction or dwarf tree species predominate, and woody plants are either greater than 6 feet in height, or cover more than one-third of the site.
4. Conifer species predominate, and the understory is dominated by lichens, mosses, low shrubs, woody shrubs, and/or reproduction. (If the primary ground fuels are duff and litter, branch wood, and tree boles, and pine needles are less than 2 inches long, then the overstory must not be decadent, and there must be only a nominal accumulation of debris.)

HEAVY FUEL CATEGORY – Covers any of the following general descriptions of vegetation in an area:

1. Deciduous broadleaf tree species predominate in an area that has been thinned or partially cut, leaving slash as the major fuel component.
2. Conifer species predominate, with duff and litter, branch wood, and tree boles as the primary ground fuels, and an overstory that is overmature and decadent, with a heavy accumulation of dead tree debris.
3. Slash is the predominant fuel in the area. (Counts as heavy fuel at any level of loading, regardless of whether settling has been significant or slight, and whether foliage is attached or falling off.)

The United States Department of Agriculture has created a site with wildfire analysis resources, at http://www.fs.fed.us/fire/science/index.html. Since USDA assesses fire risks nationwide, local or state resources will probably be needed to supplement this source in order to accurately assess a community's specific fuel model areas in the local hazard mitigation plan.

FEMA's wildfire model then combines these fuel type areas with assessments of local topography and weather patterns, to identify overall risk categories (called "moderate hazard," "high hazard," and "extreme hazard.") Topographic information provides three land categories, based on the severity of slopes present in an area. Low slope

areas have slopes less than or equal to 40%. Moderate slope areas contain slopes measuring from 40% to 60%. Steep slope areas contain slopes greater than 60%.

Weather information can produce estimates of the number of days per year with "critical fire weather" conditions. FEMA has stated that a local or state fire marshal, forestry department, or department of natural resources can help in determining the number of days per year that critical fire weather is experienced in an area.

Overall categories of wildfire risk (moderate, high, and extreme) are given by the following FEMA table:

	Frequency of Critical Fire Weather								
	1 day per year or less			2 to 7 days per year			8 or more days per year		
Fuel Classification	Slope ≤40%	Slope 41%-60%	Slope ≤60%	Slope ≤40%	Slope 41%-60%	Slope ≥60%	Slope ≤40%	Slope 41%-60%	Slope ≤60%
Light Fuel	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	High
Medium Fuel	Moderate	Moderate	High	High	High	High	Extreme	Extreme	Extreme
Heavy Fuel	High	High	High	High	Extreme	Extreme	Extreme	Extreme	Extreme

Additional factors that increase fire risk and may be included in a model include lightning and human factors such as the number of persons residing in, camping in, visiting, or traveling through an area. Such persons may increase fire risks through carelessness or ignorance, while other persons (including residents and fire spotters) may reduce risk of uncontrolled wildfire in an area, through their ongoing fire awareness, prevention, and response activities. It also makes sense to take into account the type of fire-fighting personnel, equipment, expertise, and related resources (such as water) that are available to a community, or lacking in adjacent communities (from which a fire might spread).

Vulnerable structures are those located in or near a potential wildfire area, unless they have taken special steps to become "Firewise" (as described previously). Nonflammable roof and patio materials, clearance of vegetation and maintenance of a defensible space around structures, available means to provide and facilitate site access by emergency responders, and so on, will make a structure potentially able to withstand wildfire events in its vicinity. Structures that are located in a wildland/urban interface area should be evaluated for these sorts of site features that will exacerbate or minimize their vulnerability. Certain design or landscaping features can render an at-risk structure completely vulnerable to any nearby wildfire event, and thus should be prioritized for wildfire mitigation strategies. Although risk-estimation models exist, FEMA has stated that there are no standardized methods for estimating the amount of damages and economic losses that a community will sustain from a wildfire event.

Although risk-estimation models exist, FEMA has stated that there are no standardized methods for estimating the amount of damages and economic losses that a community will sustain from a wildfire event. Hopefully, a study of the risk assessment options described in this section will enable your community to estimate the frequency of its wildfire events, based on fuel types and weather patterns. Structures in at-risk areas can then be individually assessed according to their "Firewise" characteristics. (These will be rough estimates of vulnerability based on the degree to which wildfire mitigation steps have been used at that site: see the fire protection steps at the FIREWISE web pages at http://www.firewise.org/fw_youcanuse/index.htm.) Structures that are not at all Firewise can be considered at-risk for total losses in a serious wildfire event. Structures that are partly Firewise should be at significantly lowered risk and thus the chances of a total loss should be lower. These estimates can be converted to dollar values (expected annual losses) by using information about housing values, estimates about the value of house contents, the costs of interrupted services, evacuation, road closures, and displacement. The value of total potential losses for each property in an at-risk area should be reduced in proportion to the extent to which it is Firewise. Overall loss calculations will therefore take the average annual occurrence of a fire event in vulnerable areas and multiply it by the percentage of that vulnerable area that will likely be affected (this will have to be estimated based on available wildfire response capabilities, or can be estimated from analyzing the extent of past wildfire events and how difficult they had been to control). The percentage of the vulnerable area affected can be considered to also represent the odds of a particular structure in that area being placed at risk, and so each at-risk structure can then have its value (after being reduced an appropriate percentage that reflects its Firewise characteristics) multiplied by that calculated risk of being involved in a wildfire event. The total of all individual structural losses can then be totaled to estimate an entire community's annual expected losses from wildfires.

The United States Department of Agriculture has created a site with wildfire analysis resources, at http://www.fs.fed.us/fire/science/index.html. Since USDA assesses fire risks nationwide, local or state resources will

probably be needed to supplement this source in order to accurately assess a community's specific fuel model areas in your local hazard mitigation plan.

Impact on the Public

Wildfires can cause widespread concerns and disruptions even in cases where physical damages have been prevented. Smoke, closed roadways, and infrastructure impacts may interfere with ordinary life, as well as an area's economy and planned events (including tourism). Wildfires can also directly cause structural fires to occur. (Please refer to the preceding sections about structural and scrap tire fire events for more information about these potential impacts.)

Impact on Public Confidence in State Governance

The large scale of wildfires can cause widespread concerns and disruption, smoke, closed roadways, and infrastructure impacts. Since many wildfire locations involve state lands (especially the Michigan Department of Natural Resources), major wildfire events may raise public questions about the effectiveness of governmental policies toward the maintenance and monitoring of conditions on such lands.

Impact on Responders

Wildfires involve special training, equipment, and expertise, as well as a large-scale response and different types of risks for responders, including the large areas involved, the risks of extremely rapid fire spread, and locations that are often isolated and distant. These tend to present difficulties with responder equipment staging, transport, coordination, and communications.

Impact on the Environment

Wildfire impacts on Michigan's environment can be considerable, due to the fact that Michigan has the largest state-owned forest system in the Eastern United States, as well as the fifth largest timber acreage in the country. Wildfires physically damage natural vegetation, forests, trees, shrubs, grasslands, native animals and insect species, etc, leaving black soot, deposits of peat, smolder, and charcoal-like ground cover that can contaminate the soil and underground water table. Wildfires can also cause dramatic and immediate changes or shock in vegetation, eliminating some species or causing others to appear where they were not present before the fire. Wildfires (depending on their size and burning time) are a significant source of gases and particulates in the atmosphere, including carbon dioxide, carbon monoxide, methane, non-methane hydrocarbons and oxides of nitrogen. Fire also produces large amounts of small, solid particles (particulate matter) that absorb and scatter solar radiation, exacerbating climate change conditions.

Even though many fires occur close to where human residences are located, they are a normal ecological phenomenon and serve long-term functions for vegetation and the natural environment. Wildfires burn excess brush, maintain large savannah-like openings, and restore wetlands by forcing out various unwanted brush and plants. The natural function of fires within the environment can be considered a renewal or "cleansing process" as long as the fire is not too severe.

Significant Wildfires in Michigan

Michigan has experienced many destructive wildfires. Thousands of homes (during Michigan's first century) and millions of acres of forest have been destroyed by wildfires. According to Michigan Department of Natural Resources (MDNR) and U.S. Forest Service records, over 5.8 million acres of forest in Michigan were burned between 1910 and 1949, an average of 145,000 acres per year. By comparison, it was reported that between 1950 and 1996, the MDNR and U.S. Forest Service were involved in suppressing over 46,100 wildfires that burned 390,000 acres of forest, which averages only 8,300 acres burned per year. This drastic reduction in the acres of timber burned was largely the result of (1) increased use of specialized equipment to suppress the fires, and (2) intensified efforts toward fire prevention. The following list summarizes some of the largest and most severe wildfires that have occurred in Michigan to date.

October 1871 - Lower Peninsula

The State's first recorded catastrophic fire occurred in the fall of 1871, after a prolonged drought over much of the Great Lakes region in the summer of 1871. The drought had left debris from logging and land clearing tinder dry, and as a result numerous fires burned throughout the state. These fires continued to smolder until, on October 8th of that year, gale and hurricane force winds fanned a series of fires across much of the northern Lower Peninsula. Because this tremendously destructive wildfire occurred at the same time as the great wildfires that struck Peshtigo, Wisconsin (which killed 1,300 people in a single night, and also affected Menominee County in the Upper Peninsula) and the Great Chicago Fire (which destroyed much of central Chicago), the Michigan wildfire received little publicity. However, the 1871 Michigan wildfire killed 200 people and burned 1.2 million acres. When the winds finally subsided, the fire's swath stretched from Lake Michigan across to Lake Huron. The most heavily affected area, north of Saginaw Bay, had an area 40 miles square that was completely destroyed, with over 50 people killed. The worst of the fire was over by October 19, although the fire wasn't completely extinguished for over a month.

August-September 1881 - Thumb Area

On August 31, 1881, several small fires in the Thumb came together to form a major conflagration (commonly known as the Thumb fire). A massive area of fires moved through the Thumb counties, and six days later, stopped at Lake Huron. This fire was, in many ways, more severe than the 1871 fire, since settlers had moved into the region in large numbers and logging had gotten underway. More than a million acres were burned; property loss exceeded $2 million, and 282 were killed. Like the 1871 fire, the fire of 1881 came at the end of an extremely severe drought and was the result of hundreds of land-clearing fires being brought together into a conflagration by high winds.

Summer 1896 – Ontonagon Fire

A dry summer exacerbated fire conditions and winds also helped to spread a wildland blaze to the town of Ontonagon, which saw heavy destruction as a result. More than 340 buildings were burned, and hundreds of residents were displaced to nearby farms and the nearby town of Rockland. Animals died and humans were injured, but fortunately, only one person was actually killed in the disaster.

October 1908 – Metz Fire (Presque Isle County)

Droughts in northern Michigan exacerbated wildfire conditions and threatened the town of Metz. Some of the evacuating residents tried to flee by train, but the train was wrecked near the station at Hawks by a burned out culvert, killing 14 passengers, plus two persons who lived at a nearby home. Since the train had found its path blocked by flames, it had attempted to proceed backwards toward Metz and Alpena, but had failed in the effort.

July 1911 – Au Sable-Oscoda Fire (Iosco County, and also Cheboygan, Crawford, and Otsego Counties)

Enormous wildfires ravaged the northern Lower Peninsula and caused massive destruction at the towns of Oscoda and Au Sable, whose 1,800 residents were evacuated by train and steamboat. At Cheboygan, a huge pile of sawdust had been burning for weeks and was beyond control. A railroad suffered heavy losses near Grayling, including 40 cars and two bridges. Fires at Oscoda and Alpena were reported to have started at slab yards. Damages were estimated at $100,000 in Alpena, and $500,000 in Oscoda and Au Sable. The town of Waters suffered $300,000 in damage to property and at least as much to lumber. At least 500 evacuees were sheltered at Tawas City and East Tawas. Total losses across the area were estimated as at least $1.5 million. Several casualties were reported, but the total number actually killed in the disaster was not clear from reports.

May 1968 – Crawford and Kalkaska Counties

The "Fletcher Road Fire" was started at approximately 2:45pm on May 8, 1968, by a pipeline welding crew whose company later paid out more than $90,000 in damages for timber losses. Tree mortality was almost total within an area of 4,216 acres across Kalkaska and Crawford Counties, and the fire crowned (reached the tree tops) in over 75% of that area. Crown fires like this allow the fire to advance and spread rapidly. The fire was able to "jump" across Fletcher Road and burned at a rate of approximately 2 miles per hour, which is considered to be a fast-moving fire. Smoke could be seen from as far as 20 miles away. A million-dollar gas refinement facility was placed at-risk by the fire, but protected by responder efforts.

August-September 1976 - Seney (Schoolcraft County)

In the late summer months of August and September 1976, a fire near Seney burned approximately 74,000 acres. At least part of the fire was started by lightning and quickly became uncontrollable due to an abundance of flammable material brought on by drought conditions. However, there were also problems involving prescribed, controlled burns and smoldering areas that later reignited and thus created unusual problems. The fire started on federal land and spread to state and privately owned lands. Fire suppression and damage costs exceeded $8 million.

May 1980 - Oscoda County

In May 1980, a wildfire in Oscoda County (known as the Mack Lake fire) destroyed 44 homes and buildings, forced the evacuation of 1,500 people, and killed one firefighter. A total of 24,000 acres were burned, resulting in a total property and timber loss of $2 million. The fire has been claimed to have stemmed from a prescribed burn that got out of control when it "jumped" across a highway. It has been claimed that a major wildfire occurs about every 20 to 30 years in the area.

May 1986 - Marquette County

In May 1986, multiple wildfires in Marquette County burned 7,000 acres and forced the evacuation of 4,000 people at K.I. Sawyer Air Force Base when flames spread right up to some of the housing units.

July 1988 – Escanaba (Delta County)

A large fire caused the evacuation of 60 families and the temporary closure of Highway U.S.-2. Two firefighters were injured battling what became known as the "Stockyard Fire," a name given because the fire area included a site that had previously been used as a stockyard. Again, conditions were exacerbated by regional drought effects.

May 1990 - Grayling (Crawford County)

In May 1990, a wildfire near Grayling in Crawford County (known as the Stephan Bridge Road fire) burned 76 homes and 125 other structures, 37 vehicles and boats, and over 5,900 acres of forestland, resulting in property losses of $5.5 million. The timber losses totaled another $700,000. The fire originated from a controlled burning of a pile of brush and timber accumulated from recently cleared land. The burning was initiated while snow covered the ground, and it had been presumed that the fire was completely extinguished. However, the pile rekindled approximately seven weeks later, and on May 8, ignited the Stephan Bridge Road fire. Strong winds and dry conditions helped spread the fire at a rate beyond that which could be controlled by human intervention. At one point in the fire, the rate of spread was an astonishing 277 feet per minute. Fortunately, the combination of human fire suppression and a passing weather front that produced rainfall finally contained the fire before it could do any additional damage. There were no fatalities as a result of this fire, and only one firefighter was injured from smoke inhalation. However, the property losses were significant.

May 2-7, 1999 - Champion (Marquette County), Epoufette (Mackinac County), Oscoda County

In early May 1999, a wildfire near the village of Champion in Marquette County (known as the Tower Lake fire) burned a total of 5,625 acres of forestland, destroyed at least 8 structures (about 7 more were damaged), and forced the evacuation of 450 persons in Champion as well as those in the vicinity of Fish Lake, Perch Lake, Mud Lake, eastern Michigamme, and Van Riper State Park. In addition, the fire forced the closure of US-41 and M-95 in the area of Champion and Michigamme for several days, and 10 bridges were burned. Timber losses were estimated at $12.8 million, with property losses totaling another $960,000. Aerial firefighting assets were brought in from surrounding areas to help prevent the spread of the fire into Champion, thus saving the town from destruction. At the request of the Governor, the Federal/State Forest Fire Suppression Agreement was activated by the Federal Emergency Management Agency (FEMA) to provide financial assistance to the State and eligible local agencies to cover some of the firefighting costs incurred. At about the same time as the Tower Lake fire, major wildfires were also being fought in several other locations across Northern Michigan. In Mackinac County, an 850-acre fire burned for several days near Epoufette, while another 850-acre fire burned in the Huron-Manistee National Forest in Oscoda County. In the Northern Lower Peninsula alone during that first week of May, MDNR forces fought nearly 40 wildfires. All of the wildfires were fueled by the same dry conditions that set the stage for the Tower Lake fire.

May-June 2000 - Mio (Oscoda County), Torch Lake Township / Lake Linden (Houghton County)

A wildfire that began on April 30 near Mio and was fed by extremely dry conditions consumed nearly 5,200 acres in the Huron-Manistee National Forest before being contained a week later. Nearly 300 firefighters and two aerial water tankers were deployed to suppress the fire. The fire prompted the evacuation of approximately 30 persons for a short time. Fortunately, the fire did not cause any injuries or structural damage. About a month later, on June 6, a brush fire set on a blueberry farm near Rice Lake in Torch Lake Township, Houghton County, got out of control and eventually burned over 350 acres before being contained the next day. Firefighters from the MDNR and 15 local fire departments, plus two aerial water tankers, were called to fight the blaze. The fire forced the evacuation of over 20 homes and cottages, and at one point was one-half mile wide and almost one mile long. Brisk winds pushed the fire to within one-quarter mile of homes along the shoreline of Lake Superior. However, no structures were lost and no injuries were reported.

March-April 2005 – Roscommon County

A long period of warm and dry weather affected northern Michigan from the end of March through mid April. Once the spring snow melt was completed, the fire danger rapidly increased. A number of wildfires developed in northern Lower Michigan in mid-April. The largest occurred in Nester Township in Roscommon County. This fire (of unknown origin) started on the afternoon of the 16th, and burned over 1,500 acres before it was gradually brought under control over the next several days. There was no known structural damage, though sixteen to twenty homes in the area were evacuated.

April 30 to May 1, 2006 – Oscoda County

A wildfire in Hughes Lake began early in the afternoon of April 30th, ignited by an individual burning brush in a fire pit. The fire spread northwest from Hughes Lake, thanks to southeast winds of 10 to 20 mph. The rate of spread reached as high as 2 miles per hour late in the afternoon of the 30th, with flame heights reaching 300 feet tall. Stands of jack pine, which burn very readily, contributed to the intensity of the fire. Containment activities brought the fire under control by late afternoon of May 1st, although mop-up would continue for several days after. Crews were flown in from as far away as New Mexico and Montana to fight the fire. At its height, almost 300 personnel were involved in fighting the fire. Approximately 5,950 acres of timber and brush land burned, south of M-72, east of M-18, and west of M-33. Sixteen structures and seven vehicles were destroyed—most structures were seasonal and not residential, but an American Red Cross shelter in Luzerne hosted seven persons. A number of evacuations were ordered, some as far west as M-18 in southeast Crawford County, although most residents returned to their homes within a few days. Total damage to property was conservatively estimated at $600,000. Note that this does not include costs incurred in fighting the fire, which were in excess of $800,000.

April 27-30, 2007 – Baraga County

A wildfire in Baraga, which started as a controlled burn by the U.S. Forest Service on the 27th, went out of control by the 29th, fueled by low relative humidity and strong winds gusting over 40 mph. The wildfire consumed more than 1,300 acres in western Baraga County between the 27th and 30th. More than 120 firefighters from the U.S. Forest Service and the Michigan DNR battled the blaze and helped authorities evacuate thirty homes in the Covington area. No injuries or structural damages were reported from the fire. Another fire in northwest Marquette County destroyed three structures and burned approximately 60 acres before it was brought under control on the 29th.

August 2007 – Luce County

On August 2, a lightning strike ignited a fire in central Luce County and grew to disastrous proportions, burning nearly 19,000 acres and resulting in a governor-declared State of Emergency. More than 220 personnel were involved in fire containment and suppression operations, from local, state, and federal agencies. Fortunately, the relatively remote location caused a limited number of properties to be lost. However, residents had to be evacuated three separate times during the substantial event period. Despite the substantial risks to nearby residents and facilities, efforts to obtain a federal disaster declaration were unsuccessful.

April 24, 2008 – Crawford County

Called the "Four Mile Road Fire," the cause may have been some sparks from a passing train. A Red Flag warning had been in effect when the fire started a few miles south-southeast of Grayling. The weather was warm, dry, and windy, and the fire quickly expanded to the northwest, crossing I-75 (which was closed for several hours) and eventually burning 1,300 acres. On the far south side of Grayling, a gas station and motel were threatened, but spared damage. About a half-dozen cabins near Simpson Lakes were lost (about two miles south of downtown Grayling), and $287,000 in damage was sustained by the Grayling Game Club. Total property damages from the event were estimated at $750,000, and MDNR response costs and timber damages were about $619,000. Fifty homes were evacuated, and power was lost in Grayling. By the evening, winds and temperatures went down and several periods of rain during the night helped the fire to be extinguished.

May 20 to 26, 2009 – Marquette and Baraga Counties

Southwest of Ishpeming, the "Black River Falls Wildfire" started on the afternoon of May 20 when a wind-damaged pine tree fell across a power line. The wildfire destroyed 21 homes, 12 other structures, and caused an estimated $4 million in property damage. The fire had burned 811 acres but was contained by the 22nd, and final clean-up took until the 26th. Personnel and equipment costs to fight the fire were estimated at $100,000 in Marquette County. During the same time period, in neighboring Baraga County, a "Pinery Wildfire" started in an area east of L'Anse and burned 685 acres before being contained two days later (with final clean-up also lasting until the 26th). About $50,000 in property damage was caused when flames destroyed a mobile home and damaged the Pinery Ski Lake trails area and a nearby cemetery. Firefighting costs for the Baraga event approached $125,000.

May 18 to 26, 2010 – Crawford and Kalkaska Counties

A debris fire expanded out of control and resulted in the "Meridian Boundary Fire" by about 1:30pm on May 18. A total of 8,800 acres were eventually burned by this fire, which took until May 26 to reach 95% containment. Twelve residences were destroyed, six were damaged, and 36 outbuildings were either destroyed or damaged, resulting in total property damages of about $825,000. Also on May 18, in adjacent Kalkaska County, the "Range 9 Fire" started when a controlled burn on an artillery range became uncontrolled as winds increased through the area. The Range 9 Fire burned 1,100 acres of mostly grassy areas on the Camp Grayling grounds, but also crossed over the boundary line at one point and destroyed 4 seasonal homes in Blue Lake Township, resulting in an estimated $125,000 in property damage. By late evening on the same date, that smaller fire was under control.

May 20 to 31, 2012 – Luce County

About $12 million in property damage resulted from the Duck Lake Wildfire in Luce County, which was ignited by lightning strikes from a line of thunderstorms. The fire started 14 miles north of Newberry and the simultaneous Pine Creek North Wildfire seriously affected large parts of the Seney National Wildlife Refuge. Fanned by strong south winds, the fire spread rapidly toward the shoreline of Lake Superior and forced people in the Pike Lake, Bodi Lake, Culhane Lake, and Little Lake Harbor areas to evacuate. Major roads across that area were closed. A total of 136 structures were burned (including one store and one motel) and the wildfire affected 21,069 acres before it was fully contained in mid-June. The Duck Lake event was the third largest in modern Michigan history. About $600,000 in resources were expended to fight the fire. A governor's state of disaster was declared for Luce and Schoolcraft Counties on May 25.

Programs and Initiatives

Michigan Department of Natural Resources Forest Management Division

The MDNR Forest Management Division directs and coordinates wildfire prevention, containment and suppression activities on all non-federal lands in the state, as well as Indian Reservations (under contract with the U.S. Bureau of Indian Affairs). The MDNR places great emphasis on wildfire prevention and public education, since the vast majority of wildfires in Michigan are caused by human activity. The MNDR Forest Management Division's philosophy is that preventing fires from starting in the first place, and precautionary measures around rural homes, are the best means of avoiding or minimizing wildfire losses. When conditions of extreme fire hazard exist, the MDNR can request the Governor to issue an outdoor burning ban to mitigate the potential for wildfire in all or part of the state. Such a ban restricts smoking, fireworks, and outdoor burning activities to approved locations.

Michigan Forest Fire Experiment Station

A string of disastrous wildfires in the early 20th century led to the creation of the Michigan Forest Fire Experiment Station in 1929. This Station, established by what was then the Michigan Department of Conservation (now the Department of Natural Resources) and located in Roscommon, is designed to investigate how wildfires behave, how to properly manage forest fuels, and how to use mechanized equipment to fight wildfires. Its research efforts have been invaluable in helping to prevent, contain and suppress wildfires in Michigan and across the country.

Michigan Interagency Wildland Fire Protection Association

Because the vast majority of wildfires are caused by human activity, the Michigan Department of Natural Resources established, in 1981, the Michigan Interagency Wildfire Prevention Group. It was the first such group in the nation (promoting wildfire prevention and awareness) that had the full involvement of the state's fire agencies. In 1993, the Michigan Interagency Wildfire Prevention Group was expanded to form the Michigan Interagency Wildland Fire Protection Association (MIWFPA). The MIWFPA promotes interagency cooperation in fire prevention, training, fire technology, and firefighting operations. Members of the MIWFPA include the: 1) MDNR Forest Management Division; 2) USDA Forest Service - Huron-Manistee, Hiawatha, and Ottawa National Forests; 3) USDI National Park Service - Pictured Rocks and Sleeping Bear Dunes National Lakeshores; 4) USDI Fish and Wildlife Service - Seney National Wildlife Refuge; 5) USDI Bureau of Indian Affairs; 6) Michigan Department of State Police - fire investigation; 7) Michigan State Firemen's Association; and the 8) Michigan Fire Chief's Association.

Michigan Natural Resources and Environmental Protection Act

The Michigan Natural Resources and Environmental Protection Act (1994 PA 451), Part 515, assigns responsibility for the prevention and suppression of forest fires to the Director of the Michigan Department of Natural Resources. The Act also establishes requirements for burning permits, allows the Governor to issue prohibitions against the use of fire during extreme fire hazard conditions, and allows the MDNR Director to enter into forest fire assistance agreements with other states and the federal government to control forest fires. These measures contribute to forest fire mitigation by preventing forest fires from starting in the first place, or lessening the spread of fires when they do start (and thus preventing further damage from occurring).

Solid Waste Management Act

The Michigan Solid Waste Management Act (1990 PA 264) prohibits the burning of leaves and grass clippings in municipalities with more than 7,500 population, unless a municipality has an ordinance expressly allowing such burning activities. When properly applied and enforced, this law helps prevent some wildfires, since roughly one-quarter of all wildfires are started by small residential waste fires that get out of control.

Great Lakes Forest Fire Compact

In the Great Lakes region, more than one-third of the 6,000 wildfires that occur annually are caused either by careless burning by residents or children playing with matches. The MDNR Forest Management Division is a member of the Great Lakes Forest Fire Compact in an effort to reduce these fires. The Compact is a partnership between the states of Michigan, Wisconsin and Minnesota, and the Canadian provinces of Ontario and Manitoba. Its purpose is to promote effective prevention, pre-suppression, and control of wildfires in the Great Lakes region through mutual aid and cooperation. Initiatives are implemented by committees composed of members of the Compact. An example of an activity the Compact has undertaken is the development of a fire hazard assessment for the region. Michigan took the lead on this project, and it has proven to be an extremely beneficial educational tool for communities and property owners in assessing their fire hazard potential.

The efforts of the Compact to build coordination and cooperation are based on the understanding that wildfires are multi-jurisdictional, and that suppression of fires usually requires the efforts of many groups and jurisdictions.

"Firewise Communities" Wildfire Protection Program

The MDNR is a participant in the national "Firewise Communities" Program developed by the National Wildland-Urban Interface (WUI) Fire Protection Program. The WUI Fire Protection Program is sponsored by the nation's major wildland fire agencies and the National Fire Protection Association (NFPA). In addition to the NFPA, other sponsors include the: 1) USDA Forest Service; 2) USDI; 3) USDI National Park Service; 4) USDI Bureau of Land

Management; 5) USDI Bureau of Indian Affairs; 6) USDI U.S. Fish and Wildlife Service; and the 7) National Association of State Foresters. These member agencies have been promoting "Firewise" living since 1986.

The Firewise Communities Program is designed to educate governmental officials and professionals in a wide variety of disciplines (e.g. planners, builders, engineers, architects, bankers, insurance representatives, emergency managers, land managers) on ways in which communities can be designed and built to minimize the threat from wildfires. The current focus of that educational effort is a series of Firewise Communities Workshops being held around the country. At the Workshops, participants use computerized mapping and wildfire simulations to learn how to recognize wildland -urban interface fire hazards, design Firewise homes and landscapes, deliver fire education, and integrate Firewise planning into existing and developing areas of communities. The Firewise Communities Program also produces and distributes guidance documents, videos, and software packages on wildland-urban interface fire issues.

Although the MDNR had worked with the City of Grayling in a pilot program during an effort to promote this initiative, there are at the current time no communities officially recognized as Firewise communities in Michigan.

Wildfire Prevention Week

Due to the high risk of wildfires in Michigan, the state observes Wildfire Prevention Week sometime in April every year. Most Michigan wildfires are human-caused, with one-third caused by people burning debris. An increasing number of people moving into rural areas surrounded by fire-prone vegetation makes preventing wildfires in these areas a critical public safety issue for everyone. The economic value that Michigan forests contribute, in the form of travel, eco-tourism, hunting, fishing, camping and other recreational uses, and timber-related products, is an estimated 200,000 jobs and $12 billion annually. Officials throughout Michigan have stressed that thoughtful activity by humans is critical to preventing wildfires.

Hazard Mitigation Alternatives for the Wildfire Hazard

- Proper maintenance of property in or near wildland areas (including short grass; thinned trees and removal of low-hanging branches; selection of fire-resistant vegetation; use of fire resistant roofing and building materials; use of functional shutters on windows; keeping flammables such as curtains securely away from windows or using heavy fire-resistant drapes; creating and maintaining a buffer zone (defensible space) between structures and adjacent wild lands; use of the fire department's home safety inspections; sweeping/cleaning dead or dry leaves, needles, twigs, and combustibles from roofs, decks, eaves, porches, and yards; keeping woodpiles and other combustibles away from structures; use of boxed or enclosed eaves on houses; thorough cleaning-up of spilled flammable fluids; and keeping garage areas protected from blowing embers).
- Safe disposal of yard and house waste rather than through open burning.
- Use of fire spotters, towers, planes.
- Use of structural fire mitigation systems such as interior and exterior sprinklers, smoke detectors, and fire extinguishers.
- Arson prevention activities, including reduction of blight (cleaning up areas of abandoned or collapsed structures, accumulated junk or debris, and lands with a history of flammable substances stored, spilled, or dumped on them).
- Public notification of fire weather and fire warnings.
- Prescribed burns and fuel management (thinning of flammable vegetation, possibly including selective logging to thin out some areas. Fuels cleared can be given away as firewood or made into wood chips for distribution.)
- The creation of fuel breaks (areas where the spread of wildfires will be slowed or stopped due to removal of fuels, or the use of fire-retardant materials/vegetation) in high-risk forest or other areas.
- Keeping roads and driveways accessible to vehicles and fire equipment—driveways should be relatively straight and flat, with at least some open spaces to turn, bridges that can support emergency vehicles, and clearance wide and high enough for two-way traffic and emergency vehicle access (spare keys to gates for properties should be provided to the local fire department, and an address should be visible from the road so homes can be located quickly).
- Enclosing the foundations of homes and buildings rather than leaving them open with their underside exposed to blown embers or materials.

- Safe use and maintenance/cleaning of fireplaces and chimneys (with the use of spark arresters and emphasis on proper storage of flammable items). Residents should be encouraged to inspect chimneys at least twice a year and clean them at least once a year.
- Proper maintenance and storage of motorized equipment that could catch on fire (from blown embers, etc.)
- Proper storage and use of flammables, including the use of flammable substances (such as when fueling machinery). Store gasoline, oily rags and other flammable materials in approved safety cans. Stack firewood at least 100 feet away and uphill from homes.
- Avoid building structures on hilltop locations, where they will be at greater risk from wildfires (in addition, hillsides facing south or west are more vulnerable to increased dryness and heat from sun exposure).
- Use of proper setbacks from slopes (outside of the "convection cone" of intense heat which would be projected up the slope of the hill as a wildfire "climbs" it).
- Have adequate water supplies for emergency fire fighting (in accordance with NFPA standards).
- Obtaining insurance.

Tie-in with Local Hazard Mitigation Planning

Because many means of implementing mitigation actions occur through local activities, this updated MHMP places additional emphasis on the coordination of State-level planning and initiatives with those taking place at the local level. This takes two forms:

1. The provision of guidance, encouragement, and incentives to local governments by the State, to promote local plan development, and
2. The consideration of information contained in local hazard mitigation plans when developing State plans and mitigation priorities.

Regarding the first type of State-local planning coordination, MSP guidance has included the “Local Hazard Mitigation Planning Workbook” (EMD-PUB 207), which is currently being updated for release by 2015. For the second type of State-local planning coordination, a section later in this plan summarizes hazard priority information as it has been reported in local hazard mitigation plans. Here, it will merely be noted that wildfires were identified as one of the most significant hazards in local hazard mitigation plans for the following counties: Alcona, Arenac, Benzie, Charlevoix, Clare, Crawford, Emmet, Gogebic, Grand Traverse, Hillsdale, Iosco, Iron, Kalkaska, Lake, Luce, Manistee, Marquette, Missaukee, Ogemaw, Osceola, Oscoda, Otsego, Sanilac, and Wexford.

Wildfire History for Michigan Counties – arranged by region – Jan. 1996 to Oct. 2013
(The Lower Peninsula regions are ordered by "tiers" from south to north, west to east)
Please refer to the Michigan Profile Map section for an explanation of regional divisions

COUNTY or area	Wildfire Events	Days with Event	Tot. property damage	Tot. crop damage	Injuries
Washtenaw					
Wayne					
.Livingston					
Oakland					
Macomb	2	2	$20,000		
5 Co Metro region	**2**	**2**	**$20,000**		
Berrien					
Cass					
St. Joseph					
Branch					
Hillsdale					
Lenawee					
Monroe					
.Van Buren					
Kalamazoo					
Calhoun					
Jackson					
.Allegan					
Barry					
Eaton					
Ingham					
.Ottawa					
Kent					
Ionia					
Clinton					
Shiawassee					
Genesee					
Lapeer					
St. Clair					
.Muskegon					
Montcalm					
Gratiot					
Saginaw					
Tuscola	1	1			
Sanilac					
.Mecosta					
Isabella					
Midland					
Bay					
Huron					
34 Co S Lower Pen	**0.3 avg.**	**0.3 avg.**			

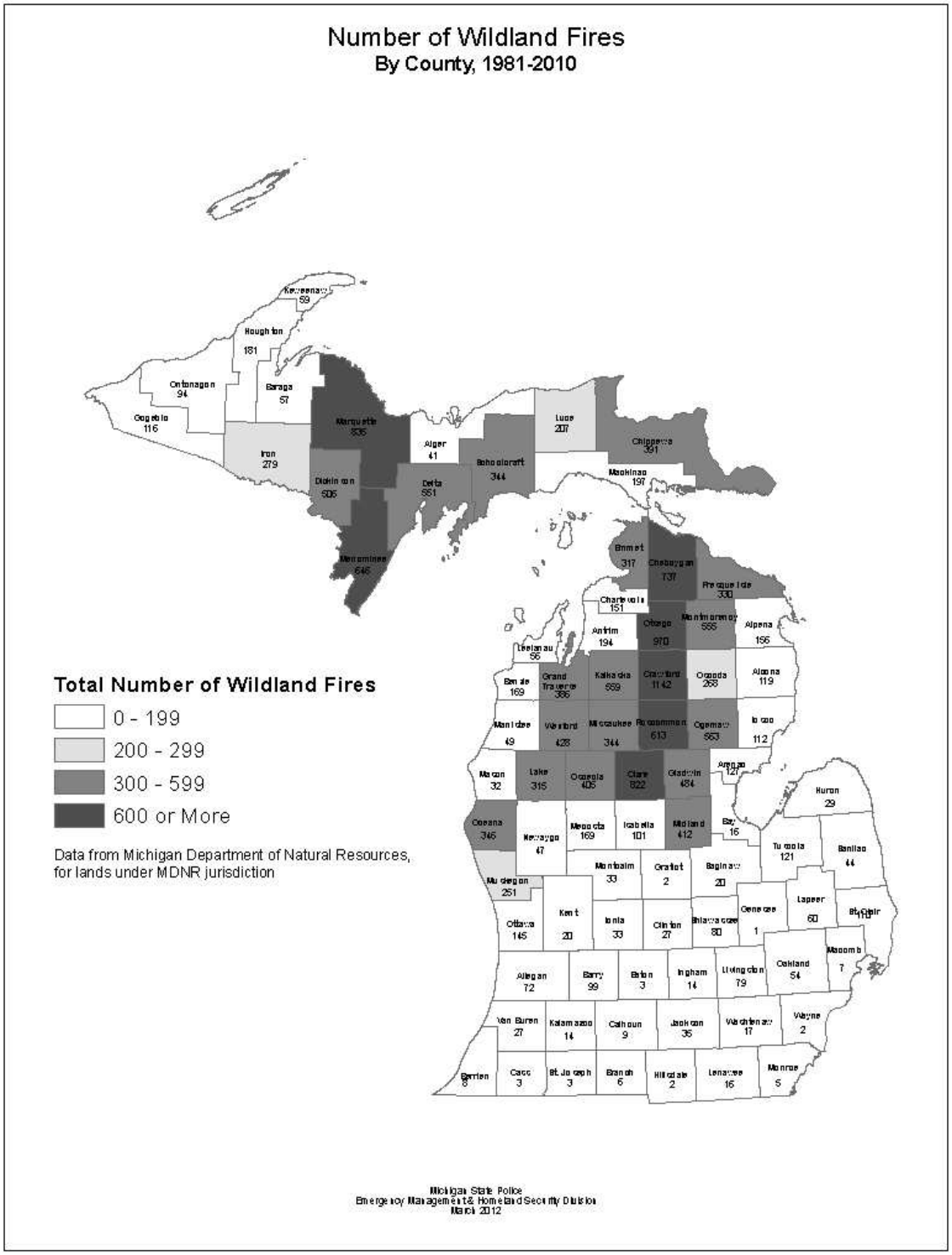
Continued on next page…

Part 2 of Michigan Counties table

.Oceana					
Newaygo					
.Mason					
Lake					
Osceola					
Clare					
Gladwin					
Arenac					
.Manistee					
Wexford					
Missaukee					
Roscommon	1	1			
Ogemaw					
Iosco	1	1	$40,000		
.Benzie					
Grand Traverse					
Kalkaska	1	1	$125,000		
Crawford	2	2	$1,575,000		
Oscoda	2	2	$600,000		
Alcona					
.Leelanau					
Antrim					
Otsego					
Montmorency					
Alpena					
.Charlevoix					
Emmet					
Cheboygan					
Presque Isle					
29 Co N Lower Pn	**0.2 avg.**	**0.2 avg.**	**$2,340,000**		
Gogebic					
Iron					
Ontonagon	1	1			
Houghton					
Keweenaw					
Baraga	2	2	$50,000		
.Marquette	7	5	$5,006,000	$1,000,000	4
Dickinson					
Menominee					
Delta					
Schoolcraft					
Alger					
.Luce	2	2	$12,040,000		
Mackinac					
Chippewa					
15 Co Upp.Pen	**0.8 avg.**	**0.7 avg.**	**$17,096,000**	**$1,000,000**	**4**
MICHIGAN TOTAL	**23**	**18**	**$19,456,000**	**$1,000,000**	**4**

Number of Wildfires, by County

(MDNR jurisdiction only)



Number of Wildfires and Acres Burned, by County: 1981-2010 (MDNR jurisdiction only)

County	Number of Wildfires	Number of Wildfires/Year* (over 30 year period)	Number of Acres Burned	Number of Acres Burned/Year* (over 30 year period)
Alcona	119	4	843.8	28
Alger	41	1	123.0	4
Allegan	72	2	312.0	10
Alpena	156	5	267.2	9
Antrim	194	6	194.1	6
Arenac	127	4	418.8	14
Baraga	57	2	1897.6	63
Barry	99	3	447.3	15
Bay	16	1	142.2	5
Benzie	169	6	279.3	9
Berrien	8	0	24.4	1
Branch	6	0	19.3	1
Calhoun	9	0	41.2	1
Cass	3	0	27.0	1
Charlevoix	151	5	492.3	16
Cheboygan	737	25	1424.0	47
Chippewa	391	13	5108.2	170
Clare	822	27	2385.6	80
Clinton	27	1	138.9	5
Crawford	1142	38	25861.5	862
Delta	551	18	3213.8	107
Dickinson	506	17	2411.0	80
Eaton	3	0	0.3	0
Emmet	317	11	543.5	18
Genesee	1	0	0.1	0
Gladwin	484	16	1938.9	65
Gogebic	116	4	245.4	8
Grand Traverse	386	13	1296.9	43
Gratiot	2	0	40.0	1
Hillsdale	2	0	23.0	1
Houghton	181	6	1200.1	40
Huron	29	1	725.5	24
Ingham	14	0	474.7	16
Ionia	33	1	728.4	24
Iosco	112	4	1630.3	54
Iron	279	9	1953.9	65
Isabella	101	3	931.8	31
Jackson	35	1	520.5	17
Kalamazoo	14	0	74.3	2
Kalkaska	559	19	2953.4	98
Kent	20	1	125.9	4
Keweenaw	59	2	375.6	13
Lake	315	11	1283.5	43
Lapeer	60	2	533.8	18
Leelanau	56	2	212.0	7
Lenawee	16	1	224.2	7
Livingston	79	3	651.4	22
Luce	207	7	18679.9	623
Mackinac	197	7	1610.6	54
Macomb	7	0	15.4	1
Manistee	49	2	1041.6	35
Marquette	835	28	16087.6	536
Mason	32	1	154.6	5
Mecosta	169	6	844.9	28
Menominee	646	22	2353.4	78
Midland	412	14	1414.9	47
Missaukee	344	11	1772.0	59
Monroe	5	0	233.3	8
Montcalm	33	1	567.6	19
Montmorency	555	19	1271.5	42
Muskegon	251	8	2675.7	89
Newaygo	47	2	404.2	13
Oakland	54	2	368.5	12
Oceana	346	12	1766.0	59
Ogemaw	563	19	8296.1	277
Ontonagon	94	3	1438.1	48
Osceola	405	14	1085.2	36
Oscoda	268	9	8765.3	292
Otsego	970	32	1924.9	64
Ottawa	145	5	469.9	16
Presque Isle	330	11	838.4	28
Roscommon	613	20	4551.9	152
Saginaw	20	1	474.7	16
Sanilac	44	1	427.3	14
Schoolcraft	344	11	3210.5	107
Shiawassee	80	3	576.7	19
St. Clair	110	4	1642.8	55
St. Joseph	3	0	7.7	0
Tuscola	121	4	930.9	31
Van Buren	27	1	249.2	8
Washtenaw	17	1	217.5	7
Wayne	2	0	42.2	1
Wexford	428	14	1057.4	35
Total DNR fire events	17449	582	152228.3	5074

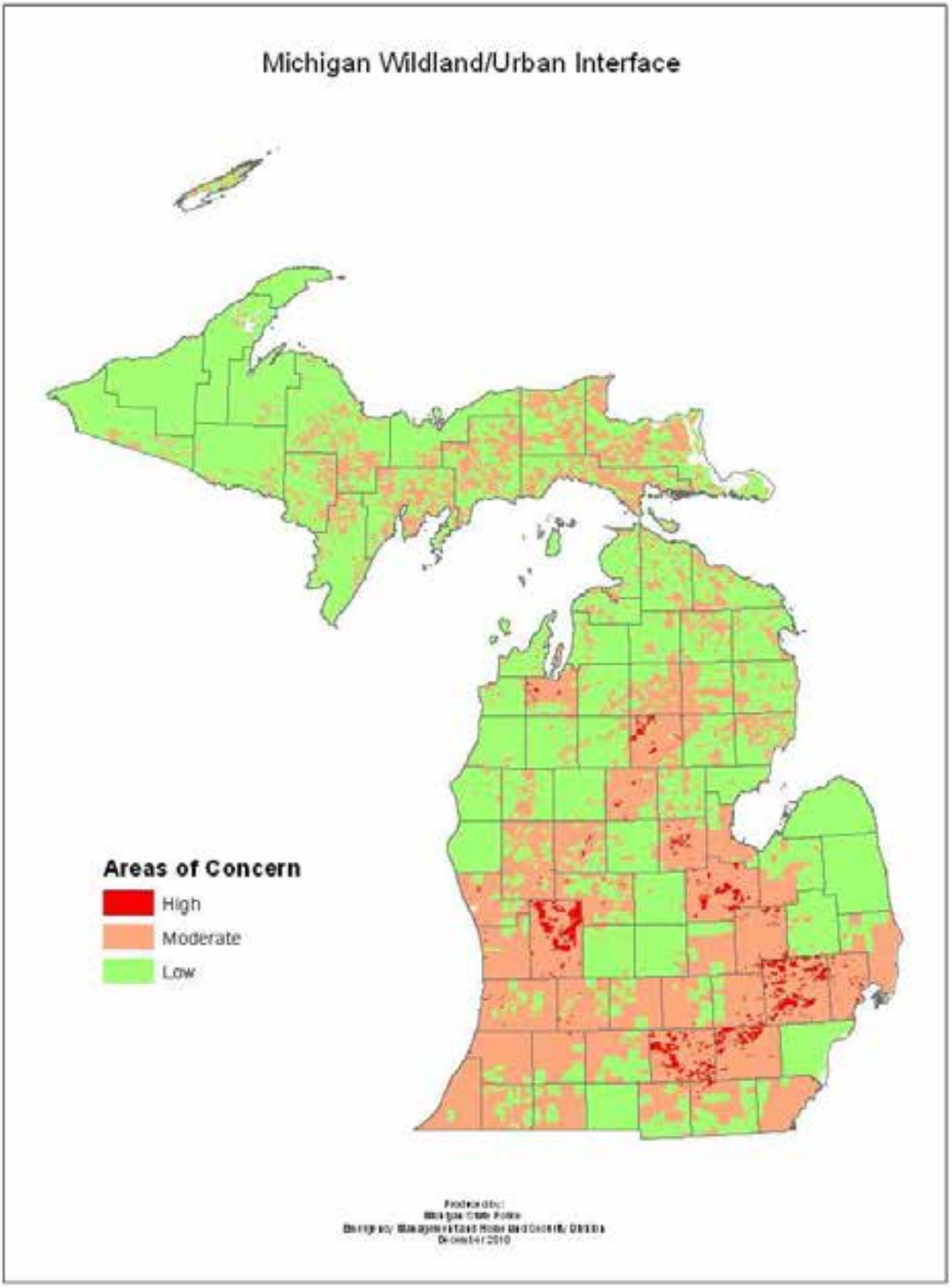
*rounded to nearest whole number

Source: Michigan Department of Natural Resources—Forest Management Division

Michigan Wildland/Urban Interface Map

Source: Michigan Department of Natural Resources, Forest Management Division

NOTE: This map is an example from a previous analysis and is being updated by more valid GIS modeling - not recommended for current use except as a highly generalized indicator



INVASIVE SPECIES

A species that has been introduced by human action to a location where it did not previously occur naturally, becomes capable of establishing a breeding population in the new location without further intervention by humans, and becomes a pest by threatening local biodiversity and causing human health impacts, significant economic costs, and/or harmful ecological effects.

Hazard Description

An invasive species is defined as a species that is (1) non-native (alien) to the ecosystem under consideration and (2) whose introduction causes or is likely to cause economic or environmental harm, or harm to human health. Invasive species can be plants, animals, and other organisms (e.g., microbes). Human actions are the primary consideration here as a means of invasive species' introduction (thus distinguishing the situation from natural shifts in the distribution of species). Nationally, the current environmental, economic, and health costs of invasive species were estimated as exceeding the costs of all other natural disasters combined.

Invasive species can be transported in many ways, such as on animals, vehicles, ships, commercial goods, produce, and clothing. Although non-native species are the foundation of U.S. agriculture, and also are used to prevent erosion, to provide fishing and hunting opportunities, and as ornamental plants and pets, occasionally a non-native organism flourishes too well and causes unwanted economic, ecological, or human health impacts. The terms "invasive" or "nuisance" are used to describe such species. New environments may affect rates of reproduction, susceptibility to disease, and other features that affect a species' success. Consequently, a plant or animal that causes little damage to agriculture or natural ecosystems in one area may cause significant problems in another. Certain non-native species are very successful in their new habitats because they out-compete native plants or animals and have no natural controls (predators, diseases, etc.) in the new area. At least 200 well-known, high-impact, non-native species presently occur in the United States. They range from the European gypsy moth and emerald ash borer to crabgrass, dandelions, and German cockroaches, annually costing well over a billion dollars to control. Some even pose human health risks. Others, like the zebra mussel, threaten widespread disruption of ecosystems and the displacement or loss of native plants and animals.

Hazard Analysis

Hundreds of new species from other countries are introduced intentionally or accidentally into the United States each year. These invasive species may arrive on our shores in a variety of ways. Transportation efficiencies that make it possible to travel around the globe in hours rather than weeks make it possible for organisms to survive transportation from one continent to another

As more adaptable and generalized species are introduced to environments already impacted adversely by human activities, native species are often at a disadvantage to survive in what was previously a balanced ecosystem. There are many examples of decreased biodiversity in such areas. One of the primary threats to biodiversity is the spread of humanity into what were once isolated areas, with land clearance and habitation putting significant pressure on local species. Agriculture, livestock, and fishing can also introduce changes to local populations of indigenous species and may result in a previously innocuous native species becoming a pest, due to a reduction of natural predators. This threat intensifies the need for scientists, managers, and stakeholders to cooperate to build better systems to prevent invasion, improve early detection of invaders, track established invaders, and to coordinate containment, control, and effective habitat restoration.

Although invasive species, in most cases, primarily cause environmental damage and degradation, there are situations in which serious threats to public health, safety, and well-being can occur due to animal disease or plant/animal infestations. For example, certain diseases could wipe out large segments of an animal population, creating a potentially serious public health emergency and the need to properly (and rapidly) dispose of the dead animal carcasses.

Similarly, a widespread insect infestation, such as that of the Emerald Ash Borer, can create serious public safety threats (especially in densely populated urban areas) due to dead and dying trees being fire prone (because of their

dry, brittle nature) or to partial/total collapse due to high winds or ice/snow accumulation. The falling trees or limbs can also bring down power lines, cause damage to public and private structures, and cause injuries or even death.

The invasive species hazard has not yet been identified as one of the most significant hazards in any of Michigan's local hazard mitigation plans.

Impact on the Public

The emerald ash borer has caused extensive damage to trees in Michigan, and those weakened trees have often (1) collapsed and caused property damage, or (2) required removal, at considerable expense. A disaster declaration request was sent to FEMA, but the request was not accepted by that agency, leaving state and local budgets, residents, and insurance companies to try to cover the considerable expenses and efforts involved in dealing with the problem. Similar terrestrial species include the Asian Long-Horned Beetle and the Cedar Long-Horned Beetle, although aquatic species and some microbes are also of concern, since they may disrupt or impede forestry, horticulture, and fishing for Michigan residents, tourists, and industries.

Impact on Public Confidence in State Governance

Terrestrial species are likely to have more general public awareness than aquatic ones, and thus more likely to be a cause for dissatisfaction or loss of public confidence in government. Although there have been well-publicized aquatic species of concern (e.g. zebra mussels, Asian carp), people tend to be more aware of the impacts of terrestrial species, unless their recreational or business activities are more heavily curtailed by aquatic ones. The most recent widespread terrestrial species of concern has been the emerald ash borer insect—trees killed by these insects are prone to collapse, causing property damage, blocked roads, broken utility lines, etc. Citizens and businesses that are more heavily connected with agriculture and tourist industries are more likely to be aware of the impact of invasive species, and thus more likely to express doubts about government policies.

Impact on Responders

The invasive species hazard is a less familiar one for the general public, generally long-term and insidious in its effects, and rooted in an understanding of the biological sciences. Most emergency management training does not focus on the topic. Emergency management consideration of invasive species is recent and therefore needs to be increased. MSP/EMHSD has recently been strengthening coordination with the U.S. Geological Survey, which has specialized offices dealing with this hazard. An Ann Arbor USGS office deals with Great Lakes aquatic species, and a separate USGS office in Fort Collins, Colorado, deals with terrestrial species. Information and resources derived from this coordination will be made available to emergency management partners, and should be promulgated through the next update of the Michigan Hazard Analysis.

Impact on the Environment

Terrestrial and aquatic forms of invasive species both pose problems for the ecosystems in which they are introduced. Whether invasive species are brought to an area on purpose or by accident, these non-native life forms can alter the existing ecosystem and decrease an area's biodiversity. Like many hazards that affect Michigan's environment, invasive species have both direct and indirect impacts. The Zebra Mussel, for example, has been invading Michigan's water bodies since the mid 1980's and is responsible for eating the microscopic food supply that is vital to the existing ecosystem. Further, the Zebra Mussel attaches to water intake pipes and screens used for drinking water and industrial plants. Not only do these pests cause environmental problems, but they cause secondary economic impacts to a community as well. Similarly, the Emerald Ash Borer, a non-native insect, is responsible for killing millions of Ash Trees in Michigan, which changes the biodiversity of the forest and diminishes wildlife habitats. Dead trees pose problems for the human-built environment, as well, pulling down nearby wires and damaging structures.

Climate Change Considerations

Different patterns of wildlife have already been concerned as a result of the lengthening average growing season in Michigan. Species that had previously been found only in warmer areas to the south have started to appear in Michigan. Although the definition of invasive species specifically refers to human species introduction, to distinguish these patterns from naturally occurring ones, species transported by human action can be more likely to survive (and thus to become invasive) as climatic changes occur.

NOTE: The following lists and descriptions provide examples of invasive species that pose some threat to Michigan, or have already affected Michigan. For each of these categories, at least several other species could have been included. Some of these species, such as the Gypsy Moth, are already well-established throughout the state, but the text provides information about the kinds of impacts that can result from the invasive species hazard.

Much additional information can be found at http://www.invasive.org/ and http://web4.msue.msu.edu/mnfi/.

Examples of Potentially Threatening Invasive Insects
(Note: Not all of these species currently occur in Michigan.)

Balsam Woolly Adelgid (Adelges piceae)
Hosts: All true firs.
Symptoms: Small white masses on tree, stunted shoots, formation of galls, tree crown turns red.
Damage: Feeding on the branches of the crown and main stem, causing mortality in 2-6 years.
Control/Treatment: Spraying of individual trees from the ground with lindane has proved effective for control. The spray, prepared by mixing 2.5 pints of 10% emulsifiable concentrate per 100 gallons of water, is applied as a bark drench with a hydraulic sprayer from May through June and September through October to control crawlers. Treatment will reduce populations to below the tree-killing level, and some treated trees may remain generally free from aphids for at least 2 years. Spraying is warranted only in accessible areas supporting relatively high-value trees.

Hemlock Woolly Adelgid (Adelges tsugae)
Hosts: Eastern Hemlocks.
Symptoms: Small white cottony masses at the base of the needles. Needles turn grayish green and drop off. There is a lack of new buds, and low vigor.
Damage: Feeding on twigs by nymphs cause the trees to die within 1-4 years.
Control/Treatment: Horticulture oils that smother the insects have been the best insecticidal treatment. The oils are non-toxic to the trees, as opposed to soap, which is an otherwise effective treatment. However, the least harmful cure may be the introduction of Japanese ladybugs.

Asian Long-Horned Beetle (Anoplophora glabripennis)
Hosts: Several species of hardwood trees found in Michigan. Its favorite host is the Norway maple, although it has been found in other maple species, horse chestnut, elm, box elder, mulberry and poplar trees.
Symptoms: Dark, wet areas on branches and trunks or white foamy sap are often the first symptoms seen in infested trees. The sap often attracts bees, wasps and hornets.
Damage: Trees infested are first weakened, and then die. Damage from these insects and secondary pests will kill a tree within a few years.
Control/Treatment: The only known way to eradicate the beetle is to cut down and burn infested trees.

Japanese Cedar Long-Horned Beetles (Callidiellum rufipenne)
Hosts: Nest in white cedar, eastern red cedar, and cypress trees.
Symptoms: Oval exit holes on tree bark, or deep irregular galleries in wood.
Damage: Larvae bore into wood and weaken the tree. Heavily infested trees may die.
Control/Treatment: None at this time.

Emerald Ash Borer (EAB) (Agrilus planipennis)
Hosts: White, black, and green ash trees.
Symptoms: Typically the upper third of a tree will die back first, followed by the rest during the next year. This is often followed by a large number of shoots or sprouts arising below the dead portions of the trunk. The adult beetles typically make a D-shaped exit hole when they emerge. Tissue produced by the tree in response to larval feeding may also cause vertical splits to occur in the bark. Distinct S-shaped tunnels may also be apparent under the bark. Adults are dark metallic green in color, 1/2 inch in length and 1/16 to 1/8 of an inch wide and are only present from mid May until late July. Larvae are creamy white in color and are found under the bark.
Damage: The adult beetles feed on ash foliage but cause little damage. The larvae feed on the inner bark of ash trees, disrupting the tree's ability to transport water and nutrients. Many trees appear to lose about 30 to 50 percent of their canopy in one year and the tree is often killed after 2-3 years of infestation. Most of the devastation in Michigan has occurred in the southeastern Lower Peninsula, where about 20 million trees have been killed. Fallen trees have caused extensive property damage. Please refer to the map at the end of this section for information about EAB quarantine areas in Michigan.
Control/Treatment: Treatment options for controlling infected or at risk trees include systemic insecticides applied as soil injections, systemic insecticides applied as trunk injections, noninvasive systemic sprays, and protective cover sprays. If properly applied, these treatment options can prevent EAB larvae from taking over the ash tree about 70% of the time. Treatment also proves to be successful when managing at-risk trees in areas where EAB has been identified. In continuing efforts to halt the expansion of the EAB, the Michigan Department of Agriculture and Rural Development (MDARD) has placed restrictions on the movement of firewood throughout the state and has taken other appropriate response measures. More information on the EAB can be found on the MDARD's website: www.michigan.gov/eab.

Gypsy Moth (Lymantria dispar)
Hosts: Tree foliage.
Symptoms: The egg mass is usually laid within a few feet of the female pupa casing. They are covered by a dense coating of hairs.

Damage: During high population levels, total defoliation can occur. During the months of June and July, defoliating populations cover sidewalks, homes, children's play equipment and other objects, making outdoor activity in residential and recreational areas almost impossible. For Michigan's nursery industry, additional expense and pesticide use are required. For the forest products industry, high gypsy moth populations mean the potential loss of wood fiber from reduced production (due to tree stress or mortality).
Control/Treatment: Counties may get involved in the Michigan Cooperative Suppression Program. The only pesticide used in the Cooperative Suppression Program is Bacillus thuringiensis, most commonly referred to as Bt.

Khapra Beetle (Trogoderma granarium)
Hosts: The beetle prefers hot, dry conditions and can be found in areas where grain and other potential food is stored, such as pantries, malt-houses, grain and fodder processing plants, and stores of used grain sacks or crates.
Symptoms: Destruction of grains and seeds. They can multiple quickly in stored items such as crackers, wheat, flour and baby cereal and rapidly spread to warehouses, storage bins, and mills.
Damage: The beetles can potentially cause severe harm to the agriculture crop industry such as grains and seeds including wheat, soybean, barley, corn and rice.
Control/Treatment: Fumigation with methyl bromide in containers to quarantining shipments until treatment. Powdered neem has been used to control the beetle in wheat stores in India.

Common Pine Shoot Beetle (Tomicus piniperda)
Note: Although previously listed in the Michigan Hazard Analysis, this species is no longer considered as damaging as it originally had been when first discovered in Michigan during the 1980s. The insect is now widespread throughout the Great Lakes and currently causes little economic impact.

Some invasive insects in Michigan, from left to right: Asian long-horned beetle, cedar long-horned beetle, emerald ash borer, gypsy moth

Examples of Potentially Invasive Microbes

(NOTE: Sudden Oak Death was described in previous editions of this plan, but has only occurred in California and Oregon. Examples listed here are not necessarily found in Michigan at the present time.)

At left, Dutch elm disease; at right, the plum pox virus

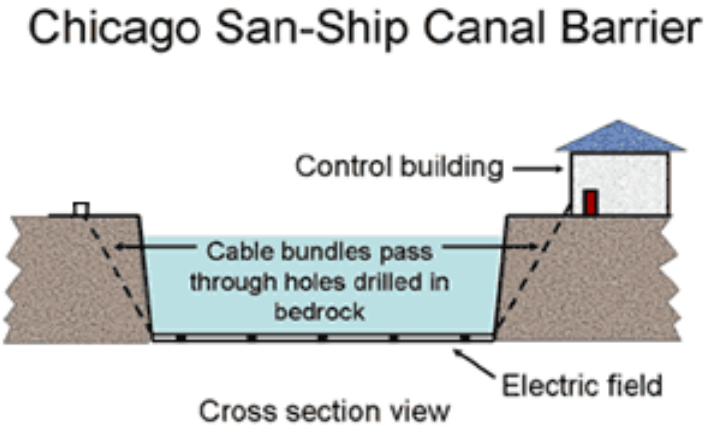
Dutch Elm Disease
Hosts: Elm trees
Symptoms: Trees infected by elm bark beetles first show wilting, curling, and yellowing of leaves on one or more branches in the upper portion of the tree, as a fungus from the beetles progressively affects the tree's health.
Damage: Large trees may survive and show progressively more symptoms for one or more years. Trees infected through root grafts wilt and die rapidly; this frequently occurs in the spring, soon after the trees have leafed out, and progresses from the base of the tree upward.
Control/Treatment: Dutch elm disease control has involved two different but related programs: (1) community-wide sanitation programs designed to reduce the level of elm bark beetles (principal carriers of the Dutch elm disease fungus); and (2) prevention of the spread of the disease through natural root grafts from infected trees to adjacent healthy trees. There are probably no community-wide programs being used any more, with a shift toward disease management involving the planting of different species of trees. There is no way to eliminate Dutch elm disease once it begins, but different species such as Siberian elms are resistant to the disease.

Plum Pox Virus
Hosts: Peach, plum, nectarine, apricot, almond, cherry.
Symptoms: Discolored viral rings on leaves and fruit.
Damage: Smaller deformed fruit and reduced fruit production.
Control/Treatment: Control and prevention measures include field surveys, use of certified nursery materials, use of virus-resistant plants (when available), control of aphids, and the elimination of infected trees in nurseries and orchards. A team of scientists from the United States and France has genetically engineered a PPV-resistant plum (known as C5), and this resistance can be transferred through hybridization to other plum trees. This provides a source of germplasm for future breeding programs worldwide. Similar success has not yet occurred in attempts to genetically modify other Prunus species.

Thousand Canker Disease of Walnut
Hosts: Black walnut and other walnut species.
Symptoms: Infected trees show wilting, curling, and yellowing of leaves on one or more branches in their upper portions, as a fungus from the walnut twig beetles progressively affects the tree's health.
Damage: Causes thousands of small cankers on and under the bark, disrupting the flow of nutrients to the branches. Tree mortality is directly proportional to the number of feeding sites present on the tree.
Control/Treatment: There is no practical treatment, once infected. Landowners should remove affected trees to prevent spread to nearby trees.

Examples of Invasive Water Species Affecting Michigan

Asian Carp (Ctenopharyngodon idella, hypophthalmichthys nobilis, and hypophthalmichthys molitrix)
Hosts: Asian carp made their way into the Mississippi River from Arkansas fish farms in the 1970s as a result of flooding and have steadily swum upstream for years at a pace of 40 to 50 miles a year. Asian carp are currently in the Illinois River and only miles away from entering the Great Lakes.
Symptoms: Decline in native fish species**.** There are three different species of Asian carp that have invaded the Mississippi River: grass (ctenopharyngodon idella), bighead (hypophthalmichthys nobilis), and silver (hypophthalmichthys molitrix). All three species of Asian carp pose a problem to the waterways by devastating habitats and destroying water quality. However, the bighead and silver carp are of the greatest concern, due to their size. These fish can each grow to be 50 to 100 pounds. Although great attention has been focused on these fish recently, dreissenid mussels have already invaded the Great Lakes and caused extensive impacts. (A description of mussels also appears in this section.)
Damage: Researchers expect that Asian carp would disrupt the food chain that supports the native fish of the Great Lakes. Due to their large size, ravenous appetites, and rapid rate of reproduction, these fish could pose a significant risk to the Great Lakes Ecosystem. If bighead or silver carp enter the great lakes, the economic impacts on the fishing industry would be devastating, putting the Midwest's multi-billion dollar-a-year fishing industry at risk. Also, silver carp have been known to cause injuries to boaters, as they jump out of the water.
Control/Treatment: To prevent the species from entering the Great Lakes, the U.S. Army Corps of Engineers, U.S. EPA, State of Illinois, International Joint Commission, Great Lakes Fishery Commission, and U.S. Fish and Wildlife Service constructed a temporary electronic dispersal barrier on the Chicago Sanitary and Ship Canal near Romeoville, Illinois, which was activated in April, 2002. In late October 2004, construction began on a second, more permanent barrier. The new barrier, completed in February 2005, stretches two rows of electrodes across the canal approximately 220 feet apart. The electrodes pulse DC current into the water, causing fish to turn back rather than pass through the electric current. The electric current poses no threat to humans. A model of the Chicago Canal Barrier can be seen below.
In November 2009, evidence of the presence of Asian carp was detected beyond the electric barrier, which left only a single lock/dam on the Calumet River between the carp's detected location and Lake Michigan. Due to the major ecological threat to Lake Michigan and to recreational boaters, the U.S. Army Corps of Engineers shut down one of the electric barriers for maintenance in December 2009. The Illinois Department of Natural Resources responded to the situation by dumping 2,200 gallons of the toxin rotenone into the canal. Rotenone is deadly for fish but not harmful to humans, animals, or most other aquatic life. The intentional fish kill cost $3 million and produced about 90 total tons of dead fish, but only one carp was found in the Lockport Lock and Dam area. In June 2010, a 19-pound Asian carp was found near the shore of Lake Michigan, in Lake Calumet, about six miles downstream from Lake Michigan, by a commercial fisherman hired by the state of Illinois to do routine fish sampling in the area. The fish confirmed existing DNA evidence suggesting that the Asian carp had indeed breached the electric barrier on the Chicago Sanitary and Ship Canal, which had been considered the last line of defense for Lake Michigan. One type of Asian Carp was recently found within the Great Lakes watershed area, but as grass carp, it was not of the type whose impact is of such widespread concern.



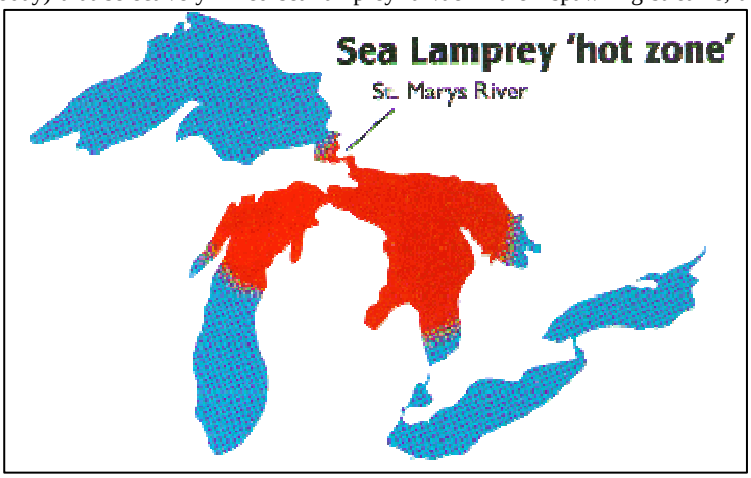
Chicago Sanitary and Ship Canal Dispersal Barrier System (Source: U.S. Geological Survey)

Sea Lamprey (Petromyzon marinus)
Hosts: Found in both fresh water and salt water habitats, they breed in freshwater streams and lakes and were first discovered in the Great Lakes in the 1800s.
Symptoms: Sea lampreys prey on a wide variety of fish. The lamprey uses its suction-cup like mouth to attach itself to the skin of a fish (possibly for days) and rasps away tissue with its sharp probing tongue and many hooked teeth, arranged in numerous rows. Secretions in the

lamprey's mouth prevent the victim's blood from clotting, and the lamprey sucks the victim's blood. Victims (usually smaller ones) typically die from excessive blood loss or infection. Mature sea lampreys average 2 to 2½ feet long, up to a maximum of about 3 feet. Sea lampreys are considered a pest in the Great Lakes region and were introduced as an invasive species in the 1800s, originating from the inland Finger Lakes and Lake Champlain in New York and Vermont. Sea lampreys created a problem for key predator fish species including lake trout, lake white fish, and lake herring. The elimination of these key predator fish allowed the alewife, another invasive species, to explode in population, having adverse effects on many native fish species.

Damage: The introduction of the sea lamprey to Lake Superior caused serious declines in fish populations, and an alteration of the ecosystem. The lake trout played a vital role in the Lake Superior ecosystem because it is considered an apex predator, which means that the entire system relies on its presence to be diverse and healthy. As an apex predator was removed from the system, the entire system felt the effects all the way down the food chain. The sea lamprey is an aggressive predator by its nature, which gives it a competitive advantage in a lake system where it has no predators and its prey lack defenses against it. The sea lamprey played a large role in the drastic decline of the Lake Superior lake trout population. One sea lamprey can upset an ecosystem and food chain by eating an estimated 40 pounds of fish or more in its lifetime. This resulted in an unbalanced relationship between predators and prey in the Great Lakes' Ecosystem.

Control/Treatment: Control efforts to mitigate the destructive effects of the sea lamprey have included the use of electric currents, chemicals, and barriers. In 1958, scientists found a chemical (still used today) that selectively killed sea lamprey larvae in their spawning streams, and brought the lamprey under control. In 1986, DNR fish managers, technicians and engineers designed a new lamprey barrier which let fish migrate through to spawn, but captured the lamprey. The new barrier was expected to reduce the number of lamprey beyond it to nearly zero. Lamprey numbers in Lake Michigan are currently only about 10 percent of their peak numbers in the 1950s. Today, biologists and researchers are still looking for new ways to stop the spread of lampreys in lakes, streams, and rivers. It is the hope of the Great Lakes Fishery Commission that at least some of this scientific work on the sea lamprey, including genetic and pheromone studies, will result in a more effective management technique that could one day drastically reduce the need for chemical treatments of spawning grounds. Several million dollars are spent each year on environmentally friendly control methods. Native predatory fish, like the whitefish and lake trout, have been restocked by fisheries professionals to help maintain a healthy level of these species.



<u>Dreissenid Mussels (including Zebra Mussels and Quagga Mussels)</u> (family Dreissenidae)

Hosts: Freshwater lakes and streams

Symptoms: By firmly attaching to hard surfaces, dreissenid mussels have clogged water-intake pipes and fouled hard-shelled animals such as clams and snails. In addition, zebra mussels have reduced plankton populations, as colonies of mussels filter large volumes of water for food, potentially depleting food resources of larval and planktivorous fishes such as smelt, chub, and alewife. Transfer of suspended material to the lake bottom in mussel waste products also leads to increased water clarity and increased growth of aquatic plants. Although clear water is often considered aesthetically pleasing, this clarity indicates that drastic changes have occurred at the base of the food web and that energy flows through the ecosystem has been altered. The mass media has given a great deal of attention to the zebra mussel, but quagga mussel infestations are actually far more extensive in the Great Lakes. Both zebra and quagga mussels belong to the same genus, dreissenid mussels, but quagga mussels are more tolerant of colder and deeper waters than zebra mussels are. Quagga mussels were first spotted in the Great Lakes around 1990, and have devoured so much plankton that the food web is being altered.

Damage: Communities along the affected lakes and rivers rely on these waters for drinking, industrial water supplies, transportation, commercial fishing and shelling, and recreation. Rapidly expanding populations of dreissenid mussels could ultimately affect many of these activities, in addition to changing the structure of the ecosystem.

Control/Treatment: Applications of hot water and bleach have been used. A new method involving bacteria is being refined.

A couple of invasive aquatic species: Asian carp and zebra mussel.

Invasive Plant Species in Michigan

Please refer to the information in the MDNR publication "Meeting the Challenge of Invasive Plants: A Framework for Action," which can be found at the following website:

http://www.michigan.gov/documents/dnr/Invasives_strategy_final_289799_7.pdf. Numerous online resources provide more information about plants, such as the NRCS database at http://plants.usda.gov/java/.

Example of a Terrestrial Animal Species that Poses a Threat to Michigan

Boar or Wild Hogs (Sus scrofa)

Feral swine are defined as free-ranging pigs and are considered to be an aggressive public nuisance. They have been known to attack and chase humans. They can become infected with, and may transmit, diseases that affect human health, domestic livestock, and wildlife, such as brucellosis, tuberculosis, bubonic plague, tularemia, anthrax, and trichinosis. In Michigan, pseudorabies-positive feral swine were removed from private land in 2008. Feral swine have the potential to cause great economic harm to the domestic swine industry, if they were to transmit such disease to commercial swine.

The appearance of feral swine may vary greatly, as they can originate from several subspecies, including the Russian Boar, the wild Eurasian boar, escaped domestic swine, and quite often a mix of domestic and wild-type breeds. These animals can weigh up to 400 pounds, may be covered in coarse hair, may have tusks, and are known to travel in groups. Females in warm states produce two large litters of 8 to 10 piglets per year. In Michigan, feral swine are known to survive the harsh winters. Feral swine tend to follow creeks and drains between food sources. They favor agricultural crops, but when the crops are harvested in the fall, they turn to wildlife food plots, acorns, and other mast foods. Feral swine are known to eat ground nesting birds, small mammals, and grubs.

Damage: Feral swine can tear up the landscape, killing wildlife and pets, damaging farm crops and wildlife habitats, and scavenging uncovered garbage. Their devastating effect on crops accounts for up to $1.5 billion in annual damages nationally. Unlike most animals, feral swine don't stop at just eating crops. They also root holes in the ground as deep as a foot, destroying the crops. Wild hogs can damage as much as 10 percent of a farmer's crop.

To date, the Department of Natural Resources has logged 288 unofficial feral swine sightings by residents in almost every county in Michigan. Since 1999, national experts have estimated that, if unchecked, the feral swine population could become established statewide and cause economic hardship for farmers, and for businesses that cater to wildlife enthusiasts.

Control: On May 13, 2010, the Michigan Legislature amended Public Act 328 of 1976 (Domestic Animals Running at Large) by allowing people to pursue and harvest feral swine at any time. The law does the following: (1) declares swine running at large on public or private property to be a public nuisance, (2) permits a local animal control officer or a law enforcement officer to kill swine running at large on public or private property, (3) permits a person with a concealed weapon permit or a valid hunting license to kill swine running at large on public property, and (4) permits a property owner or other authorized person to kill swine running at large on private property. In the last case, the landowner does not need a hunting license.

Michigan residents who see or shoot a feral pig are asked to report it to the Michigan Department of Natural Resources at (517) 336-5030. USDA Wildlife Services (517-336-1928) and the Wildlife Conservancy (517-641-7677) have feral swine traps available for the use of landowners who are experiencing feral swine damage. The animals will be trapped, removed, and tested for disease, then euthanized and disposed of.

In December, 2010, the Michigan Department of Natural Resources classified feral swine as an invasive, exotic or prohibited species under Public Act 451, the state's Natural Resources and Environmental Protection Act of 1994, but the Director's order does not go into effect until April of 2011.

Partners: The Feral Swine Working Group is an interagency team of veterinarians, biologists, and policy personnel within the state and federal governments, Michigan State University, and from numerous stakeholder groups, including the Michigan Animal Control Association, Michigan Farm Bureau, Michigan Pork Producers Association, Michigan United Conservation Clubs, Michigan Corn Growers Association, the Nature Conservancy, United Deer Farmers of Michigan, the Michigan Hunting Dog Federation, and the Michigan Wildlife Conservancy.

Animal Diseases

There are many animal diseases that have the potential to impact Michigan. Diseases from outside Michigan or the United States have the potential to cause widespread mortality in livestock, wildlife, and companion animals. They could result in huge economic losses (primarily through trade restrictions), require significant resources to be allocated for response, and in some cases could also threaten public health. For more information, please refer to the Reportable Animal Diseases documents of the Department of Agriculture and Rural Development. (One introductory link is: http://www.michigan.gov/mda/0,1607,7-125-48096_48097_48155-71720--,00.html.) Foot and Mouth Disease is an example of a foreign animal disease that would require a heightened response from Michigan agencies.

Example of a Livestock Disease That Poses a Threat to Michigan

Foot and Mouth Disease

Hosts: This infectious virus spreads on surfaces and in the air, and impacts cattle, swine, sheep, goats, deer, and other cloven-hoof ruminant animals. It does not currently exist in Michigan or the United States and has not existed in the U.S. since 1929. However, the disease is of great concern because it is highly contagious and would have grave economic consequences for Michigan's livestock industry.

Symptoms: In cattle, blisters inside the mouth that lead to excessive secretion of stringy or foamy saliva and to drooling; and blisters on the feet that may rupture and cause lameness. Adult animals may suffer weight loss from which they do not recover for several months, as well as swelling in the testicles of mature males. In cows, milk production can decline significantly.

Damage: Though most animals eventually recover from FMD, the disease can lead to myocarditis (inflammation of the heart muscle) and death, especially in newborn animals. Some infected animals do not suffer from or show signs of the disease, but they are carriers of FMD and can transmit it to others.

Control/Treatment: The Michigan Department of Agriculture and Rural Development (MDARD) licenses and regulates Michigan's 500 livestock dealers, truckers, livestock sales, and auction markets to help monitor animal health and ensure the safe and humane handling of animals. The MDARD also monitors and controls the interstate and intrastate shipment of animals and animal products, to eradicate and control

the spread of disease. If this disease were discovered in the United States, it would trigger national and state response plans and require rapid and coordinated response in order to control the disease and protect the nation's livestock industry.

Wildlife Diseases that Pose a Threat to Michigan

Chronic Wasting Disease (CWD)

This is a prion disease of the brain. The infectious agent contaminates the environment and is transmitted from one animal to another.

Hosts: Deer and elk are affected by this brain disease that is present in several western states and in Minnesota and Wisconsin. It was also detected in one Michigan location in 2008 (at an enclosed deer breeding facility in Kent County). Mule deer, white-tailed deer, and Rocky Mountain Elk are the only three species of the family Cervidae that are known to be naturally susceptible to CWD. However, it is very likely that other subspecies of C. elaphus are susceptible to the disease. Although no other deer in Michigan have tested positive for CWD (outside of the isolated Kent County case), it remains a major concern due to the large wild population of deer in the state.

Symptoms: Emaciation, wide stance, lowered head, droopy ears and excessive salivation.

Damage: Animal fatalities

Control/Treatment: Chronic wasting disease is both transmissible and infectious, but most details of its transmission remain to be determined. No treatment is available for animals affected with CWD. Once clinical signs develop, CWD is invariably fatal. Affected animals that develop pneumonia may respond temporarily to treatment with antibiotics, but ultimately the outcome is still fatal. Similarly, no vaccine is available to prevent CWD infection in deer or elk.

Two threatening animal diseases: Chronic wasting disease and foot and mouth disease.

Programs and Initiatives

Note: These listings highlight the breadth of existing programs and initiatives currently under way, but are not intended to be comprehensive.

Michigan Aquatic Nuisance Species (ANS) Program

In 1996, Michigan developed its first comprehensive ANS state management plan to provide guidance on actions for the prevention, control, and impact-management for ANS that have invaded, or may invade, Michigan waters. This state management plan was updated in 2002, and includes a summary of accomplishments, goals, and activities. The MDNR was awarded funding through the Great Lakes Restoration Initiative in 2010, to update and continue the implementation of the plan. A core team of staff members and managers from the Fisheries, Wildlife, Water Resources, Recreation, and Law Enforcement Divisions (of the DNR and DEQ), as well as representatives from the Pesticide and Plant Pest Management Divisions (of the Department of Agriculture and Rural Development) and the Project Planning Division (of MDOT) are currently in the initial stages of updating the state management plan. The plan is accessible at http://www.michigan.gov/documents/deq/deq-ogl-ANSPlan2002_249062_7.pdf.

These efforts include the Asian Carp Control Strategy, which includes studies performed by the U.S. Army Corps of Engineers. The USACE Asian Carp Study stems from a nearly 80 million dollar initiative from the White House Council on Environmental Quality in 2007, involving a multi-pronged federal attack against Asian Carp. The Asian Carp study examines the possibility of permanently shutting down the Chicago waterway system that links Lake Michigan to the Mississippi River Basin, and coordinating state efforts in response to the Asian carp threat. Although some actions may be taken before the study is completed, a final recommendation on how to stop the movement of the Asian Carp and other related species is expected to be made by 2013. However, the USACE has been accused of moving too slowly to prevent Asian carp and other exotic species from invading the Great Lakes. The USACE will release a short list of possible solutions in 2013 to quicken the process. The USACE will pick up the pace under a revised strategy in which it no longer will devise a single preferred method. Instead, the agency will put forward several options and leave it to congress and the public to decide.

Proposed Legislation to Prevention Asian Carp Invasion

Due to Asian Carp being detected beyond established barriers and less than six miles from direct access to the Great Lakes, a bill (The Permanent Prevention of Asian Carp Act) was created to direct the U.S. Army Corps of Engineers to study the watersheds of the Illinois, Chicago, and Calumet Rivers, and their tributaries, that drain directly into Lake Michigan, to determine the feasibility and best means of implementing the hydrologic separation of the Great Lakes and Mississippi River basins to prevent the introduction or establishment of populations of aquatic nuisance species along that pathway. In 2010, this bill was introduced in the U.S. House of Representatives (H.R. 5625) and the U.S. Senate, but it was merely referred to committee (and thus "died"). Numerous similar legislative efforts have suffered similar fates or otherwise not been acted upon, such as the Asian Carp Prevention Act of 2013. The latest congressional bill is H.R. 4001, the Defending Against Aquatic Invasive Species Act of 2014, which was rated as having a slightly higher chance of making progress than the earlier efforts.

The Sea Lamprey Control Program

Administered by the Great Lakes Fishery Commission, this program may be the best example of integrated pest management in North America. The program costs over $20 million per year, but has been tremendously successful in protecting the multi-billion dollar Great Lakes fishery for millions of persons who fish or are involved in a related sector of the economy. Sea lamprey control efforts have resulted in a 90% reduction in sea lamprey populations throughout the Great Lakes. http://www.glfc.org/lampcon.php

National Strategy and Implementation Plan for Invasive Species Management

The National Strategy and Implementation Plan for Invasive Species Management was developed by a team of researchers and specialists. This plan is responsible for preparing the Forest Service to deal with the ecological and economic problems associated with the types of invasive species that affect the nation. The plan maps out a strategic direction for Forest Service programs, which include Research and Development, International Programs, State and Private Forestry, and the National Forest System.

Animal and Plant Health Inspection Service

The Animal and Plant Health inspection Service (APHIS) is responsible for protecting and promoting U.S. agricultural health, administering the Animal Welfare Act, and carrying out wildlife damage management activities. The APHIS mission is an integral part of U.S. Department of Agriculture's (USDA) efforts to provide the nation with safe and affordable food. In recent years, the scope of APHIS' protection function has expanded beyond pest and disease management. Because of its technical expertise and leadership in assessing and regulating the risks associated with agricultural imports, APHIS has assumed a greater role in the global agricultural arena. Now, the agency must respond to other countries' animal and plant health import requirements and negotiate science-based standards to ensure that America's agricultural exports, worth over $50 billion annually, are protected from unjustified trade restrictions. In response to needs expressed by the American people and Congress, APHIS' protection role also includes wildlife damage management, the welfare of animals, human health and safety, and ecosystems vulnerable to invasive pests and pathogens. In carrying out its diverse protection responsibilities, APHIS makes every effort to address the needs of all those involved in the U.S. agricultural sector.

The United States Geological Survey (USGS)

The U.S. Geological Survey plays an important role in federal efforts to combat invasive species in natural and semi-natural areas. USGS services include the early detection and assessment of newly established invaders, the monitoring of invading populations, contributions to the understanding of the ecology of invaders and the understanding of factors involved in the resistance of habitats to invasion. The USGS is also involved in the development and testing of prevention, management, and control methods. USGS science centers conduct research relevant to invasive species in Michigan, and these are located at La Crosse, Wisconsin (the Upper Midwest Environmental Science Center), and Ann Arbor, Michigan (the Great Lakes Science Center). Each state in the U.S. is also home to a USGS Water Science Center, some of which conduct or support research relevant to invasive species in the Great Lakes.

The USGS maintains databases that may assist with the monitoring and reporting of invasive species occurrences, as well as provide information on their control. A couple of examples of these resources include the Nonindigenous Aquatic Species Database, at http://nas.er.usgs.gov, and the National Biological Information Infrastructure (NBII), an electronic information network that provides access to biological data and information on the nation's plants, animals,

and ecosystems. Sophisticated modeling capabilities, to predict the potential distribution of invasive species, are also available through the National Institute of Invasive Species Science in Fort Collins, Colorado.

NOAA Great Lakes Environmental Research Laboratory (GLERL)

This agency includes research on aquatic invasive species, and focuses on the biological and ecological effects of these species in the Great Lakes, and on the prevention of new species introductions. GLERL houses the NOAA National Center for Research on Aquatic Invasive Species (NCRAIS), which helps to coordinate the agency's aquatic invasive species outreach efforts across the U.S.

Eastern Michigan University Detroit River International Wildlife Refuge Study

Researchers from Eastern Michigan University made an effort to study and help contain the spread of invasive species at the Detroit River International Wildlife Refuge, along 5,700 acres of the Detroit River and Lake Erie. In November 2010, EMU was awarded $487,000 by a program that is part of the National Oceanic and Atmospheric Administration. The purpose is to expand upon work that had examined the spread of phragmites australis (which impairs the refuge's economic and environmental viability), that had set up monitoring points, looked at efforts to control the reed, and also measured effects on water quality. The purple loosestrife and reed canary grass are among the invasive plant species that also might be studied. For the next phase of the project, researchers plan to use a combination of on-the-ground surveys, water quality analysis, and remote satellite detection of invasive species to study their spread. Locations will be mapped, and data will be presented in a new way that is designed to help refuge officials in making management decisions.

Michigan Invasive Plant Council

The Michigan Invasive Plant Council (MIPC) is a non-profit organization that spans a wide array of groups, including government agencies, commercial enterprises, conservation organizations, educational institutions, and the gardening public. MIPC is an affiliate organization of the Southeast Exotic Pest Plant Council and its mission is to protect Michigan from the threat of invasive species. The council develops and publishes an invasive species list; facilitates the exchange of information concerning the management, control, and monitoring of invasive plants; provides a forum for all interested parties to discuss issues relating to invasive plants; serves as an educational, advisory, and technical support council for all aspects of invasive plants and related issues; and helps to prevent future introductions of new invasive plants.

Emerald Ash Borer (EBA) Awareness Week

EAB Awareness Week provides information on the steps that everyone can take to prevent the spread of EAB infestation, as well as fostering a cooperative spirit between citizens, communities, government and industry to reduce the risk that the insect poses to the 700 million ash trees blanketing the state. During the week and throughout the year, the Michigan Department of Agriculture and Rural Development (MDARD) urges Michigan residents and visitors to learn about EAB, be on the look-out for and immediately report possible signs of infestation, and adhere to the State's order banning the transport of ash trees, materials and all firewood from quarantined areas. Each spring, many outreach, education and compliance activities are planned (or will be highlighted) to help increase awareness and understanding of the EAB. The EAB Awareness week is typically held during the last week in May.

Michigan Chronic Wasting Disease Task Force-Final Report

In 2003, Governor Granholm signed an executive order creating a task force to address the threat of Chronic Wasting Disease in Michigan's deer and elk populations. The task force includes five members appointed by the Governor, who serve as the voting members of the task force. The directors of the Department of Agriculture (now MDARD), Community Health, Natural Resources, Environmental Quality, State Police, and Transportation serve as non-voting members of the task force. In October of 2003, the task force presented its findings and recommendations in a report delivered to the Governor. The report can be found at www.michigan.gov/cwd.

Michigan Cooperative Suppression Program – Gypsy Moth Infestations

The main goal of the Cooperative Suppression Program is to provide technical and funding assistance to county governments. This allows them the opportunity to provide protection from severe gypsy moth populations. The objectives are 1) to reduce the risk of severe defoliation and 2) to reduce the nuisance created by large caterpillar numbers. A county, interested in participating in the Cooperative Suppression Program, enters into an agreement with MDARD to conduct the program. MDARD provides training, technical support and operational guidelines to the

county. The training and guidelines are used to identify areas for treatment. The State of Michigan enters into a contract with an applicant for treatment of the qualified areas and the county is granted up to 50% cost-share for the cost of conducting the program.

Aquatic Invasive Species Awareness Week

In a continued effort to raise public awareness about the negative impacts caused by aquatic invasive species, the State of Michigan has established the Aquatic Invasive Species (AIS) Awareness Week, usually the second week in June. An aquatic invasive species is defined as a waterborne, non-native organism that threatens the diversity or abundance of native species, the ecological stability of impacted waters, or threatens a commercial, agricultural, aquacultural, or recreational activity. The AIS Awareness Week recognizes that Michigan's expansive shorelines and inland waters draw millions of tourists and recreational users each year, and that appropriate preventive steps must be taken to protect the state's water resources from invasive aquatic species. The AIS Awareness Week is sponsored by the MDEQ's Office of the Great Lakes, working in collaboration with other state and federal agencies as well as private and nonprofit organizations.

Some Hazard Mitigation Alternatives for Invasive Species

- Restrictions on the import and transport of species carriers.
- Adjustments to hunting, fishing, and other policies and regulations related to wildlife populations.
- Use of barriers to prevent invasive species travel.
- Use of competing species or other population control techniques.

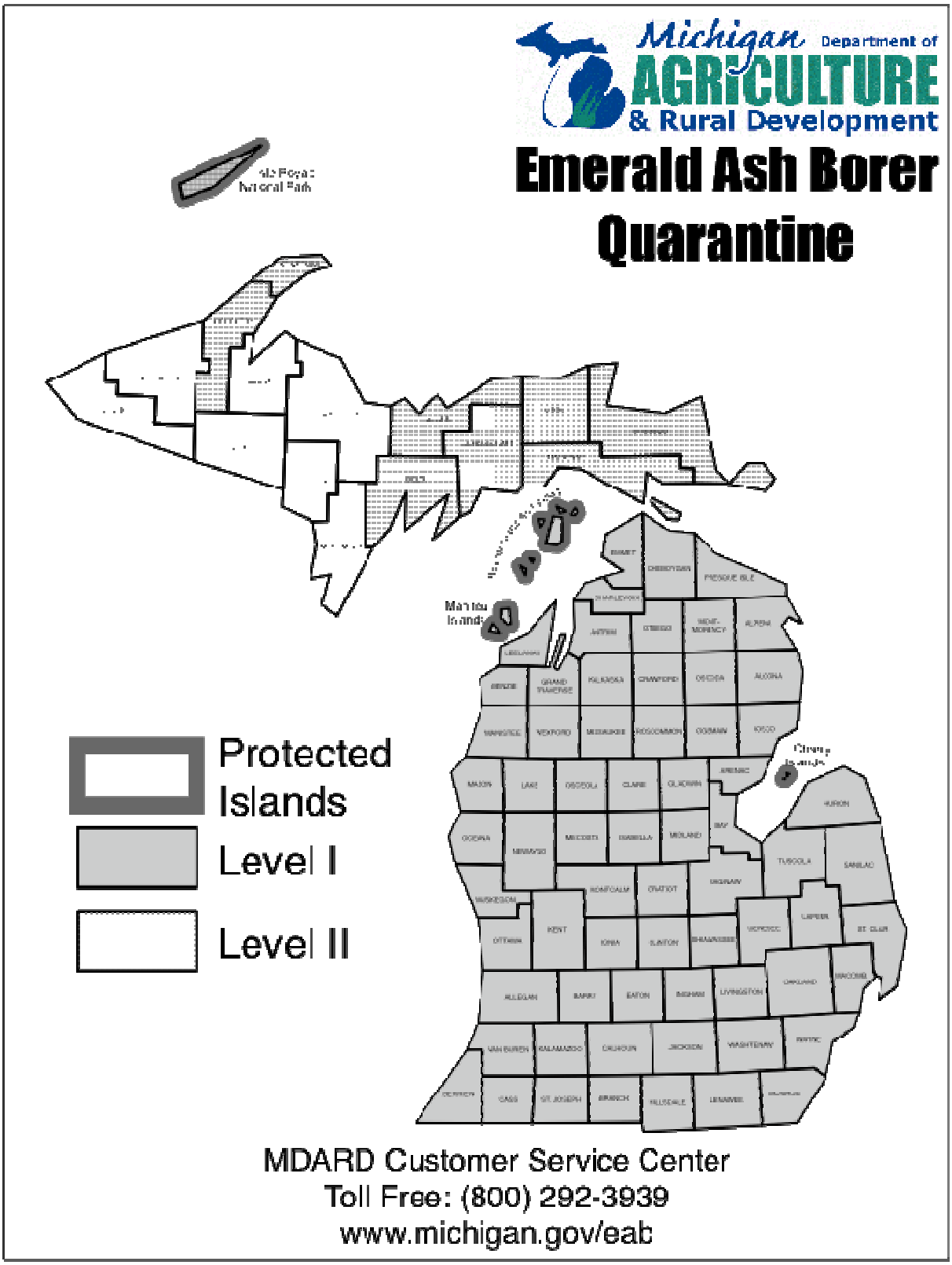
Tie-In With Local Hazard Mitigation Planning

Because many means of implementing mitigation actions occur through local activities, this updated MHMP places additional emphasis on the coordination of State-level planning and initiatives with those taking place at the local level. This takes two forms:

1. The provision of guidance, encouragement, and incentives to local governments by the State, to promote local plan development, and
2. The consideration of information contained in local hazard mitigation plans when developing State plans and mitigation priorities.

Regarding the first type of State-local planning coordination, MSP guidance has included the "Local Hazard Mitigation Planning Workbook" (EMD-PUB 207), which is currently being updated for release by 2015. For the second type of State-local planning coordination, a section later in this plan summarizes hazard priority information as it has been reported in local hazard mitigation plans. Here, it will merely be noted that no local hazard mitigation plans have yet identified invasive species as one of their top hazards.

Emerald Ash Borer Quarantine Area Map, as of early 2014



Source: Michigan Department of Agriculture and Rural Development

I. Natural Hazards
D. Geological Hazards

The following outline summarizes the significant geological hazards covered in this section:

1. Ground Movement
    a. Earthquakes
    b. Subsidence
2. Celestial Impacts

Although some states recognize "landslides" as an additional hazard, Michigan's geology and history tends to make it more prone to land subsidence instead. Michigan's two main vulnerabilities to ground movement are therefore identified in the sections on earthquakes and subsidence hazards. Erosion is not in itself typically considered an emergency event, except in cases involving encroachment into shoreline developments near a river or lake, and these have been dealt with in the Hydrological Hazards section of this plan. A new section of this plan, celestial impacts, deals not only with the impact of physical objects on property, but also with the effects of solar storms on our modern infrastructure. It will be seen that the systemic technological impacts of this hazard involve greater expected risks than the more well-known impacts of a meteoritic type. Although meteorite impacts are quite easy to understand and visualize, and do have a small potential to be catastrophic, it is the seemingly abstract and mostly invisible effect of "space weather" that has the greatest probability of causing widespread disruption and harm in the near future.

Overlap Between Geological Hazards and Other Sections of the Hazard Analysis

The most serious Michigan earthquakes would be expected to damage some of the utilities infrastructure in the southern part of the state, and could contribute to the occurrence of an energy emergency. Some flooding could result from broken water mains. There may be some potential for oil and gas pipeline operations to be disrupted, as well. A serious subsidence event may cause a key roadway to collapse and become unusable, and may also cause certain other types of infrastructure to become exposed and vulnerable. Transportation accidents that may result from these hazards could cause the release of dangerous hazardous materials. The real potential for a catastrophic incident exists in the event of a major seismic event involving the New Madrid fault line.

Celestial impacts involving solar flares can cause infrastructure failures and have the potential to cause major transportation accidents involving airplanes and/or seagoing vessels. Other types of celestial impacts, involving the impact of physical bodies upon the Earth and its atmosphere, are usually minor but rarely will have the potential to be catastrophic, capable of causing damage equivalent to a nuclear attack and the associated casualties, mass fires (including wildfires), infrastructure failure, severe winds, and physical damages associated with the nuclear attack hazard (but without as intense of radiological effects).

Earthquakes

A shaking or trembling of the crust of the earth caused by the breaking and shifting of rock beneath the surface.

Hazard Description

Earthquakes range in intensity from slight tremors to great shocks. They may last from a few seconds to several minutes, or come as a series of tremors over a period of several days. The energy of an earthquake is released in seismic waves. Earthquakes usually occur without warning. In some instances, advance warnings of unusual geophysical events may be issued. However, scientists cannot yet predict exactly when or where an earthquake will occur. Earthquakes tend to strike repeatedly along faults, which are formed where tectonic forces in the earth's crust cause the movement of rock bodies against each other. Risk maps have been produced which show areas where an earthquake is more likely to occur. Earthquake monitoring is conducted by the U.S. Geological Survey, the National Oceanic and Atmospheric Administration, and universities throughout the country.

The actual movement of the ground in an earthquake is seldom the direct cause of injury or death. Most casualties result from falling objects and debris. Disruption of communications systems, electric power lines, and gas, sewer and water mains can be expected. Water supplies can become contaminated by seepage around water mains. Damage to roadways and other transportation systems may create food and other resource shortages if transportation is interrupted. In addition, earthquakes may trigger other emergency situations such as fires and hazardous material spills, thereby compounding the difficulties of the situation.

A fault line is where a fault meets the ground's surface, but many faults dip at an angle away from their surface location, and therefore earthquakes that occur at some depth will often not line up with the fault at the surface. Faults do not only occur at the boundaries of large geological plates. There are many small plates that exist, as well as faults that are internal to or perpendicular to plate boundaries.

Hazard Analysis

No severely destructive earthquake has ever been documented in Michigan. However, several mildly damaging earthquakes have been felt since the late 1700s. The exact number is difficult to determine, as scientific opinion on the matter varies. With most of these earthquakes, damage (if any) was limited to cracked plaster, broken dishes, damaged chimneys, and broken windows.

In recent years, attention has been focused on the New Madrid Seismic Zone. This zone extends from approximately Cairo, Illinois through New Madrid, Missouri to Marked Tree, Arkansas. During the winter of 1811-1812, a series of earthquakes shook the area. The three worst earthquakes destroyed the town of New Madrid, created a 17,000 acre lake in Northwestern Tennessee, and caused ocean-like swells on the Mississippi River. Richter Scale estimates ranged around 8.0. The 1811-1812 earthquakes also included hundreds of aftershocks, some with magnitudes estimated to be between 6.5 and 7.6 on the Richter Scale.

The New Madrid Seismic Zone is significant because scientists predict that a catastrophic earthquake (between 6.0 and 7.6 on the Richter Scale) will occur within the zone sometime during the next few decades. Michigan may be somewhat affected by such an earthquake. A repeat of the 1811-1812 earthquakes is unlikely in the near future. However, should it occur, it could result in damage, disruptions, casualties, and injuries on a scale never experienced from an earthquake in the history of the U.S. The immediate and long-term relief and recovery efforts could place a significant, prolonged burden on the regional and national economies.

Fortunately, Michigan is not located in an area subject to major earthquake activity. Although there are faults in the bedrock of Michigan, they are now considered relatively stable. However, these faults are poorly mapped. According to the U.S. Geological Survey, although Michigan is in an area in which there is a low probability of earthquake occurrences, the area may be affected by distant earthquakes that occur in the New Madrid Seismic Zone and upstate New York. The New Madrid Seismic Zone poses the most significant threat. Based on recent scientific studies, portions of southern Michigan could be expected to receive minor damage were such an earthquake to occur (see the map at the end of this section).

The greatest impact on the state would probably come from damage to natural gas and petroleum pipelines. If the earthquake occurs in the winter, many areas of the state could be severely impacted by fuel shortages. Damage would probably be negligible in well-designed and constructed buildings. However, poorly designed and constructed buildings could suffer considerable damage under the right circumstances.

The following table has a list of earthquakes that have been felt in Michigan. The most severe event centered in Michigan was the 4.7 magnitude event of 1947, which caused some damage to (mainly residential) structures in the southwest region of the Lower Peninsula.

Tectonic Earthquakes Felt or Occurring in Michigan

Date	Origin	Magnitude
4-20-1793*	Porcupine Mt, MI	N/A
12-16-1811 (3 events)	New Madrid, MO	7.9, N/A., N/A
1-22-1812	New Madrid, MO	N/A
1-23-1812	New Madrid, MO	N/A
1-25-1812	New Madrid, MO	7.0
2-3-1812	New Madrid, MO	N/A
2-7-1812	New Madrid, MO	7.5
2-8-1812 (4 events)	New Madrid, MO	N/A
10-20-1870	La Malbaie, QUE	N/A
8-17-1877*	Greenfield, MI	3.2
9-19-1884	Lima, OH	4.8
9-1-1886	Charleston, SC	7.7
10-31-1895	Charleston, MO	6.7
5-26-1909	Aurora, IL	5.1
3-1-1925	La Malbaie, QUE	7.0
8-12-1929	Attica, NY	5.2
11-1-1935	Timiskaming, QUE	6.2
3-2-1937	Anna, OH	5.0
3-9-1937	Anna, OH	5.4
2-12-1938*	Porter, IN	4.0
3-13-1938*	Gibraltar, MI	3.8
3-14-1938*	Gibraltar, MI	N/A
3-9-1943	Lake Erie, OH	4.5
9-5-1944	Massena, NY	5.8
8-10-1947	Coldwater, MI	4.7
11-9-1968	El Dorado, IL	5.5
9-15-1972	Rock Falls, IL	4.5
4-3-1974	Lancaster, IL	4.7
2-2-1976	Pt. Pelee, ON	3.4
7-27-1980	Sharpsburg, KY	5.1
8-20-1980	Harrow, ON	3.2
11-29-1982	Scotts, MI	2.5
10-7-1983	Blue Mtn. Lake, NY	5.1
1-31-1986	Perry, OH	5.0
7-12-1986	St. Mary's, OH	4.6
6-10-1987	Lawrenceville, IL	5.2
11-25-1988	Saguenay, QUE	5.9
9-2-1994	Central Michigan	3.4
9-25-1998	Sharon, PA	5.2
10-23-2001*	Prairie Lake, MI	2.9
4-18-2008 (2 events)	West Salem, IL	5.4, 4.8
2-10-2010	Elgin, IL	3.8
6-23-2010	Val-Des-Bois, QUE	5.0

N/A means that the magnitude information was not available.
* May not have been a natural earthquake. Explosive blasting, mine collapse or other subsidence, and large meteorite impacts can all cause tremors to be felt that may give persons the impression that an earthquake has occurred.
Source: Michigan State University Earthquake Information Center / East Lansing Seismic Station

NOTE: This list has been adapted from the "Earthquakes in Michigan" source list found at https://www.msu.edu/~fujita/earthquake/eqinfo.html. Earthquakes that may not have actually been felt in Michigan were not included in the list.

Historical earthquake occurrences appeared to have an element of a cyclical nature about them, with some decades containing numerous events, surrounded by decades with only a few events, and followed by periods with nearly no occurrences at all. Over time it may be that (probably due to increases in population and development) the number of occurrences gradually increases within this cycle, although this is uncertain. (The pattern is not extremely clear and long, and may just happen to be a statistical artifact.) The potential pattern is illustrated through the listing of natural tectonic earthquake events by decade, with arrows pointing to small peaks of earthquake activity approximately every 50 years. (This is shown on the next page.)

The hypothesis that there may be a kind of cyclic trend is based purely upon the historical data. A recent text, Michigan Geography and Geology (editor in chief, Randall Schaetzl), includes a chapter on earthquakes and states that "about once every 50 years, a magnitude 3-4 event occurs within the state, south of a line between Grand Rapids and Pontiac." Although the event information (listed above) had fit pretty well into this pattern, the most recently updated information from the same source has not quite fit perfectly into the proposed pattern, for instead of the earthquake activity dropping to zero after a clear peak during the 1980s, it has instead fallen into a pattern of about two events per decade, and one of those decades (the 2010s) has only just begun! Thus, there seem to be more earthquakes being felt recently than might have been expected, according to the previous pattern. It is possible that this level of disturbance might be comparable to the periods that would have been marked with zeroes in the past, and that the next occurrence of a peak (in the 2030s?) may therefore involve a record number of events, if there is indeed a gradual trend toward an increased number of disturbances.

1790s:	0	
1800s:	0	
1810s:	12	←These were all New Madrid events and aftershocks, and may not fit into a cyclic trend for Michigan
1820s:	0	
1830s:	0	
1840s:	0	
1850s:	0	
1860s:	0	
1870s:	1	
1880s:	2	←Possible peak in a cyclic trend
1890s:	1	
1900s:	1	
1910s:	0	
1920s:	2	
1930s:	3	←Possible peak in a cyclic trend
1940s:	3	
1950s:	0	
1960s:	1	
1970s:	3	
1980s:	8	←Possible peak in a cyclic trend
1990s:	2	
2000s:	2	
2010s:	2	←Recent trend might not quite match the proposed 50-year cycle

Earthquake Risk Calculation

Although earthquakes are generally not considered a major hazard in Michigan, other states have had so many problems with this hazard that very detailed techniques have been developed to estimate earthquake risks. Each area of the country has been assessed by geologists (according to types of bedrock, fault line proximity, and other factors) and sorted into general zones of earthquake risk. (For a national map showing this, see the web site at http://earthquake.usgs.gov/research/hazmaps/.) These zones are expressed in terms of a probability that significant ground movements will be felt. For example, there may be a 10% chance of an area experiencing significant ground movement within a 50 year period, (which is similar to the "500-year" floodplain, since the annual probability of such an event calculates as roughly .0021). Another component of risk calculation would be to estimate the amount of damage that is likely when such an event occurs. Official measures use the concept of Peak Ground Acceleration (PGA, which is also abbreviated as %g). The key task is to translate the severity of (PGA) ground motion into estimates of structural damages and other economic costs. FEMA has developed a computer application (HAZUS) to give estimates of these earthquake effects.

Michigan has a comparatively low risk of experiencing damaging ground movements. Because of this low risk, however, many designers and developers did not take into consideration the possibility that an earthquake *might* occur. Some of Michigan's communities may actually be quite vulnerable to earthquake effects—especially Michigan's underground utilities—in cases where developed areas were not designed to withstand any ground movements.

Urban areas and active mineland/quarry areas may experience seismic effects as a result of blasting activities, subsidence, structural collapses, vibrations from trains and trucks, or explosions (such as from industrial accidents or terrorist activity). It is therefore worth considering a strengthening of infrastructure as well as interior design enhancements to resist both natural and other types of seismic impacts, vibrations, and stresses.

Impact on the Public

Earthquakes have the potential to cause impacts on an area's infrastructure and energy if a significant event occurs. Impacts could include higher prices for energy and supplies, and the potential for limited supplies of needed goods and resources. A major event, such as a large-scale temblor in the New Madrid Zone, may constitute a National Emergency event (on the scale of Hurricane Katrina), in which there is a need for mutual aid to be provided to states which were strongly affected, and the intake of evacuees from those states. There is a moderate potential for property damage to occur in areas of southern Michigan that are more prone to experiencing seismic activity, and these damages would clearly be inconvenient for homeowners and businesses, at the very least.

Impact on Public Confidence in State Governance

The public may perceive earthquake effects in terms of a governmental failure to plan for and maintain appropriate standards for infrastructure durability and hardening. Some questions may also be raised about whether sufficient

geological research had been conducted in the area, and about whether there was a successful means of providing advance warning that the area might experience an earthquake.

Impact on Responders
Response operations have the potential to include search and rescue activities, which involve special risks and requirements for training and equipment. Earthquake-related infrastructure failures or road subsidence may inhibit efficient and safe response to the incident, and may interfere with the access and use of resources needed for normal and emergency response activities.

Impact on the Environment
A significant earthquake has the potential to cause problems for the environment, both directly and indirectly. Ground movement may disrupt wildlife habitats and change an area's landscape. Secondary environmental impacts caused by a significant event may involve a hazardous materials release into the ground, air, or water from damaged buildings and infrastructure. Fortunately, it is unlikely that an earthquake, even a significant-magnitude New Madrid event, would cause great environmental impacts in Michigan.

Programs and Initiatives
The Federal government has several programs and initiatives in place to help reduce the earthquake threat, two of which impact Michigan. The most recent, and perhaps most prominent, is the development of the National Response Framework (NRF) to coordinate federal assistance to a catastrophic earthquake or other similar disaster. Coordinated through the federal Department of Homeland Security (DHS), the NRF outlines the responsibilities of all federal agencies with a role in disaster response and/or recovery. Should a catastrophic earthquake ever impact Michigan, federal response and recovery assistance would be coordinated under the provisions set forth in the NRF.

In January 1990, Executive Order (EO) 12699, Seismic Safety of Federal and Federally Assisted or Regulated New Building Construction, was signed into law. This EO requires that appropriate seismic design and construction standards and practices be adopted for any new construction or replacement of a federal building or federally regulated building receiving federal assistance. The purpose of this EO is to reduce risks from failure of federal buildings during or after an earthquake.

Hazard Mitigation Alternatives for the Earthquake Hazard
The biggest Michigan threats would be to pipelines, buildings that are poorly designed and constructed, and shelving, furniture, mirrors, gas cylinders, etc. within structures that could fall and cause injury or personal property damage.

- Adopt and enforce appropriate building codes.
- Use of safe interior designs and furniture arrangements.
- Obtain insurance.
- "Harden" critical infrastructure systems to meet seismic design standards for "lifelines."

Tie-in with Local Hazard Mitigation Planning
Because many means of implementing mitigation actions occur through local activities, this updated MHMP places additional emphasis on the coordination of State-level planning and initiatives with those taking place at the local level. This takes two forms:

1. The provision of guidance, encouragement, and incentives to local governments by the State, to promote local plan development (including a consideration of earthquakes), and
2. The consideration of information contained in local hazard mitigation plans when developing State plans and mitigation priorities.

Regarding the first type of State-local planning coordination, the information immediately following provides advice regarding the earthquake hazard to offer guidance to local planners, officials, and emergency managers. It has been adapted from the February 2003 “Local Hazard Mitigation Planning Workbook” (EMD-PUB 207). For the second type of State-local planning coordination, a section follows that summarizes earthquake information as it has been reported in local hazard mitigation plans. For a brief summary of earthquake-related information from that section of this plan, it will here be noted that earthquakes were identified as one of the most significant hazards in the local hazard mitigation plans for Cass and Dickinson counties.

Earthquake Guidance for Local Hazard Mitigation Planning

Although earthquakes are generally not considered a major hazard in Michigan, other states have had so many problems with this hazard that very detailed techniques have been developed to estimate earthquake risks. Each area of the country has been assessed by geologists (according to types of bedrock, fault line proximity, and probably other factors) and sorted into general zones of earthquake risk. (For a national map showing this, see the web site at http://earthquake.usgs.gov/research/hazmaps/.) These zones are expressed in terms of a probability that significant ground movements will be felt. For example, there may be a 10% chance of an area experiencing significant ground movement within a 50 year period, (which is similar to the "500-year" floodplain, since the annual probability of such an event calculates as roughly .0021). The other component of risk calculation would be to estimate the amount of damage that is likely when such an event occurs. Official measures use the concept of Peak Ground Acceleration (PGA, which is also abbreviated as %g). All that remains is to translate the severity of (PGA) ground motion into estimates of structural damages and other economic costs. The earthquake analysis should use historic data to estimate the extent to which different types of structures would be affected by different severities of ground movement that are likely to regularly occur in your area. The extent of damage can then be expressed in terms of the value of the structure, its contents, and its functional and economic significance for the community. FEMA has developed a computer application (HAZUS) to give estimates of these earthquake effects.

Michigan has a comparatively low risk of experiencing damaging ground movements. Because of this low risk, however, many designers and developers did not take into consideration the possibility that an earthquake *might* occur. Some of Michigan's communities may actually be quite vulnerable to earthquake effects—especially Michigan's underground utilities—in cases where developed areas were not designed to withstand any ground movements. Detailed earthquake risk analyses in Michigan could identify facilities or infrastructure that *might* be at-risk, and then have engineers calculate the degree of actual vulnerability to those facilities. Engineers should be able to estimate potential damages and calculate structural reinforcement costs to see if earthquake mitigation measures are economically justifiable.

Urban areas and active mineland/quarry areas may experience seismic effects as a result of such things as blasting activities, subsidence, structural collapses, vibrations from trains and trucks, or explosions (such as from industrial accidents or terrorist activity). It is therefore worth considering a strengthening of infrastructure as well as interior design enhancements to resist both natural and other types of seismic impacts, vibrations, and stresses.

Modified Mercalli Intensity Scale (and Michigan map)

The map on the next page shows the worst anticipated impact upon Michigan from a major New Madrid earthquake event. The level of impact is described in terms of numeric categories along the following scale:

I – Not felt by people

II – People at rest or in tall buildings may feel movement

III – Many indoors feel movement; hanging objects swing; like the vibrations from a light truck passing by

IV – Most persons indoors feel movement, and a few persons outdoors; like the vibrations from a heavy truck passing by

V – Almost everyone feels movement; dishes break, and small unstable objects move; liquids may spill

VI – Everyone feels movement; many run outdoors; walking is difficult; breakables fall and break; plaster may crack **[NOTE: This is the worst level of severity known to potentially affect Michigan.]**

VII – Cars shake; chimneys, tiles, and plaster may fall from buildings; slight damage to well-built buildings; considerable damage to poorly built buildings

VIII – Difficulty steering cars; tall structures and chimneys may fall

IX – Well-built buildings may suffer considerable damage; houses can move off their foundations; underground pipes break

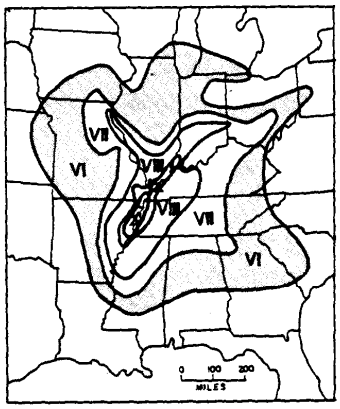
X – Most buildings and foundations are destroyed

XI – Most buildings collapse

XII – Almost everything in the area is destroyed

Earthquake Threat in Michigan

Source: U.S. Geological Survey



Regional map of maximum intensities that would result from a magnitude Ms=7.6, maximum intensity earthquake *anywhere* along the New Madrid Seismic Zone.

The map shows an approximate area where the worst damage might occur (Intensity VI). North of the shaded region could experience Intensity V effects. If another line is drawn, parallel to that demarcating the northern limit of the Intensity VI area, but shifted northward to include the "Thumb area" of Michigan, then that would approximate the area with Intensity V potential effects from the worst New Madrid earthquake event. Most of the rest of the state would experience a maximum of Intensity IV effects from such an event.

Subsidence

The lowering or collapse of a land surface, caused by natural or human-induced activities that erode or remove subsurface support.

Hazard Description

Subsidence is the lowering or collapse of a land surface, due to loss of subsurface support. It can be caused by a variety of natural or human-induced activities. Natural subsidence occurs when the ground collapses into underground cavities produced by the solution of limestone or other soluble materials by groundwater. Human-induced subsidence is caused principally by groundwater withdrawal, drainage of organic soils, and underground mining. In the United States, these activities have caused more than 17,000 square miles of surface subsidence, with groundwater withdrawal (10,000 square miles of subsidence) being the primary culprit. In addition, approximately 18% of the United States land surface is underlain by cavernous limestone, gypsum, salt, or marble, making the surface of these areas susceptible to collapse into sinkholes.

Hazard Analysis

Generally, subsidence poses a greater risk to property than to life. Nationally, the average annual damage from all types of subsidence is conservatively estimated to be at least $125 million. The National Research Council estimate of annual damage from various types of subsidence is outlined in the table below:

Land Subsidence: Estimated Annual National Damage

Type of Subsidence	Annual Damage ($)
Drainage of organic soils	40,000,000
Underground fluid withdrawal	35,000,000
Underground mining	30,000,000
Natural compaction	10,000,000
Sinkholes	10,000,000
Hydrocompaction (collapsible soils)	N/A
TOTAL:	**$125,000,000**

Source: National Research Council; Multi-Hazard Identification and Risk Assessment, Federal Emergency Management Agency

Mine Subsidence

In Michigan, the primary cause of subsidence is underground mining. Although mine subsidence is not as significant a hazard in Michigan as in other parts of the country, many areas in Michigan are potentially vulnerable to mine subsidence hazards. Mine subsidence is a geologic hazard that can strike with little or no warning and can result in very costly damage. Mine subsidence occurs when the ground surface collapses into underground mined areas. In addition, the collapse of improperly stabilized mine openings is also a form of subsidence. About the only good thing about mine subsidence is that it generally affects very few people, unlike other natural hazards that may impact a large number of people. Mine subsidence can cause damage to buildings, disrupt underground utilities, and be a potential threat to human life. In extreme cases, mine subsidence can literally swallow whole buildings or sections of ground into sinkholes, endangering anyone that may be present at that site. Mine subsidence may take years to manifest. Examples of collapses occurring decades after mines were abandoned have been documented in several areas of the country.

Michigan's Mining Experience

Michigan's rich mining heritage has played a significant role in the State's development into a world economic power. Due to its diverse geology, Michigan has a wide variety of mineral resources, most notable of which are copper ore, iron ore, coal, sand, gravel, gypsum, salt, oil and gas. It is not surprising then that underground mining has occurred on a significant scale throughout Michigan's history. The principal types of underground mining that occurs, or has occurred in Michigan, include coal mining, metallic mineral mining, salt mining, gypsum mining, and solution mining.

Copper Mining

Copper mining, in particular, put Michigan on the map as a major mining area. Although native copper ore occurs in other parts of the world, at one time the quantity of Michigan's native ore was unsurpassed. From the mid to late 1800s, Michigan's Keweenaw Peninsula mines produced more native copper ore than any other mining area in North America. As those resources became depleted, copper mining began near White Pine in Ontonagon County. The target strata in the White Pine mining operations were on an anticline that was mined both at depths as shallow as 100 feet and as deep as 2900 feet. Over-mining of pillars in shallow parts of the mine caused collapse and subsidence at the surface, on mine property, during the 1980s. The "Copper County" area generally crosses Ontonagon, Houghton, and Keweenaw Counties.

Iron Ore Mining

Michigan's Lake Superior region has been home to significant iron ore mining operations since the mid-1800s. The iron producing areas are referred to as ranges, since the iron deposits generally occur on the slopes or at the base of remnants of ancient mountain ranges. Michigan has three ranges: 1) Gogebic Range, which extends from Gogebic County into Wisconsin; 2) Marquette Range, in Marquette County; and 3) Menominee Range, in Dickinson and Iron Counties. Most near-surface iron deposits in these three ranges have been exhausted, so underground mining has become the primary extraction technique. Nearly two billion tons of iron ore have been extracted from these areas. Unfortunately, economics have forced the closure of many of the underground iron mining operations, although one company still mines in the region. The "Iron Range" area generally includes the five counties of Baraga, Dickinson, Gogebic, Iron, and Marquette.

Salt/Solution Mining

Michigan also has one of the world's largest underground salt accumulations. The thickest salt beds lie under most of the Lower Peninsula. These formations are, in some places, over 3,000 feet thick and composed of layers of salt and other minerals. Michigan ranked first or second in national salt production from 1880 to the late 1920s. The bulk of the salt production was from natural brines pumped from six salt formations. Salt was also produced from artificial brines that were derived by injecting freshwater into salt formations and retrieving the resulting brines (called solution mining). The old Detroit salt mine produced rock salt using the "room and pillar" method until 1983. (The room and pillar method involves creating large underground expanses [rooms] in which to mine, supported by pillars [natural or artificial structural members] that held in place the roofs of these rooms.) The Detroit salt mine was approximately 1,100 feet below ground, and encompassed approximately 1,100 acres of subsurface land. The room and pillar method is being used only in the single salt mine that is still operating in Michigan, by the Detroit Salt Company, which has an excellent safety record. Salt is also being produced from brines extracted at various locations within the state.

Gypsum Mining

Gypsum has been mined in Michigan since 1841. In the Grand Rapids area, gypsum is mined by the "room and pillar" method. Open pit mining is used in the Alabaster region (Iosco County). In both of these areas, gypsum beds directly underlie thin layers of glacial drift. Closed topographic lows observed in both areas are believed to be due to groundwater solution of the gypsum and subsequent collapse of the overlying material.

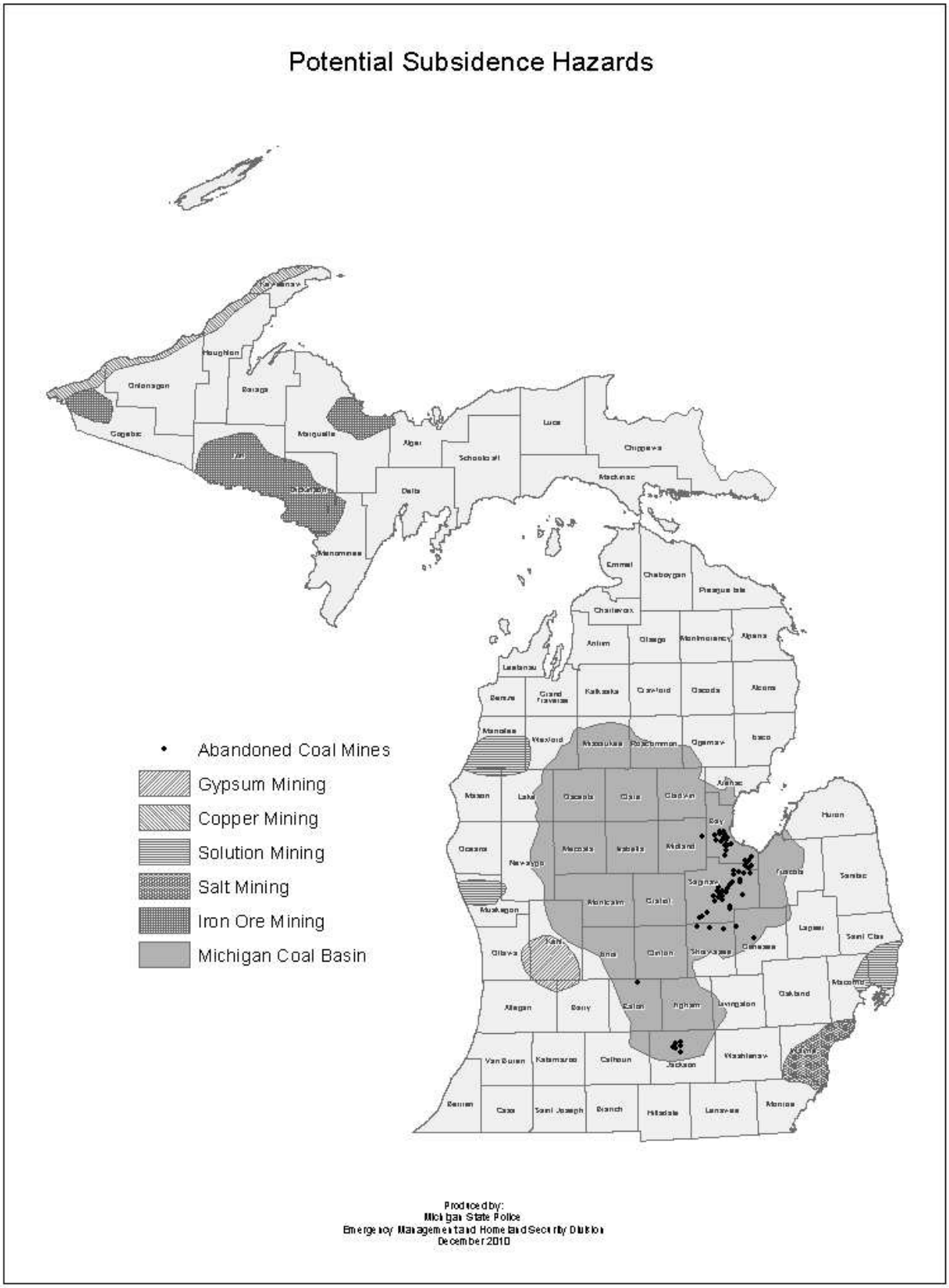
Coal Mining

Michigan also once supported a thriving coal mining industry. Records indicate that over 165 different coal mines operated in Michigan's coal-bearing region, which includes 31 counties in the south-central portion of the Lower Peninsula. Over 100 of the 165 known coal mines in the state were located in the Saginaw Bay area. (See the map on the following page for an outline of Michigan's Coal Basin.) Coal was first discovered in Michigan in 1835 in Jackson County. From that discovery, several small underground and surface coal mines were opened in that area of the state. In 1861, coal was discovered near Bay City, and in 1897 commercial coal mining began in Bay County. That led to the establishment of numerous additional mines in Saginaw, Tuscola and Genesee counties, which tended to be larger, deeper and more extensive mines. That was the start of Michigan's coal mining industry.

The state's underground coal mines were an average of 110 feet deep, and were worked by the "room and pillar" method. Michigan had continuous coal mining from 1897 to 1952, when the last underground coal mine near St. Charles, Saginaw County, closed. From 1860 (the year mine records were first kept) until 1975 (the year the last surface coal mine closed), the 165 commercial coal mines produced a total output of over 46 million tons of coal. The maximum coal output was achieved in 1907, when Michigan's 37 operating coal mines produced two million tons per year - enough to supply 16% of Michigan's then total demand for coal.

Mine-Related Subsidence Threats in Michigan

Source: Michigan Department of Environmental Quality, Office of Geological Survey



Mine Subsidence Problem in Michigan

The legacy of underground mining can be felt in numerous locations across the state. Many of the underground mining areas, whether active or abandoned, are vulnerable to subsidence in some form. The map on the previous page indicates the areas in the state that are potentially vulnerable to mine subsidence. Unfortunately, records of abandoned mines are often sketchy and sometimes non-existent. Therefore, it is often difficult to determine exactly where the mines were located. Many areas of Michigan may have developed over abandoned mines and may not even be aware of it. Oftentimes, the only way a community or home / business owner becomes aware of a potential hazard is when subsidence actually occurs and damage or destruction results.

Water-Related Subsidence

Compaction of soils in some aquifer systems can accompany excessive ground-water pumping and cause subsidence. Excessive pumping of such aquifer systems has resulted in permanent subsidence and related ground failures. In some systems, when large amounts of water are pumped, the subsoil compacts, thus reducing in size and number the open pore spaces in the soil that previously held water. This can result in a permanent reduction in the total storage capacity of the aquifer system. More than 80% of the identified subsidence in the United States is a consequence of human impact on subsurface water. Three distinct processes account for most of the water-related subsidence: compaction of aquifer systems, drainage and subsequent oxidation of organic soils, and dissolution and collapse of susceptible rocks.

An increasing number of urban subsidence events have resulted from infrastructure failures, such as water main breaks, which cause road surfaces to collapse. Construction-related incidents have also occurred in Michigan.

Mining Ground Water

Groundwater in the pore spaces of an aquifer supports some of the weight of the overlying materials. When groundwater is depressurized or even removed from aquifers, where the materials are very compressible and pore pressures can be high, compaction may occur. This subsidence may be partially recoverable if pressures rebound, but much of it is not. Thus the aquifer is permanently reduced in capacity, and the surface of the ground may also subside. The picture on the next page shows the unconsolidated aquifer systems in Michigan

Drainage of Organic Soils

Land subsidence may occur when soils rich in organic carbon are drained for agriculture or other purposes. The most important cause of this subsidence is microbial decomposition, which, under drained conditions, readily converts organic carbon to carbon-dioxide gas and water. Compaction, desiccation, erosion by wind and water, and prescribed or accidental burning can also be significant factors. The picture on the next page shows the location of the organic soils in Michigan.

Collapsing Cavities

This type of subsidence is commonly triggered by ground-water-level declines caused by pumping and by enhanced percolation of ground water. Collapse features tend to be associated with specific rock types, such as evaporites (salt, gypsum, and anhydrite) and carbonates (limestone and dolomite). These rocks are susceptible to dissolution in water and the formation of cavities. Salt and gypsum are much more soluble than limestone, the rock type most often associated with catastrophic sinkhole formation. Evaporite rocks underlie about 35 to 40% of the United States, though in many areas they are buried at great depths. Collapse sinkholes may develop over a period of hours and cause extensive damage. The picture on the next page shows the location of the evaporite and carbonate rocks in Michigan.

Water-Related Subsidence Problems in Michigan

In the past there has been pressure for the Great Lakes states to export bulk quantities of water to various locations in the United States. If these plans to withdraw large amounts of water from the Great Lakes ever took place, it may have a major effect on the level of the ground water tables in Michigan, which may possibly make subsidence a more common occurrence. Currently, broken water pipes and the improper discharge of rainwater are the most common causes of water-related subsidence in Michigan. It most commonly occurs on sandy or silty ground when the water from the leak washes out the fine particles beneath the foundation, causing voids that result in collapse or subsidence.

Water-Related Subsidence Threats in Michigan

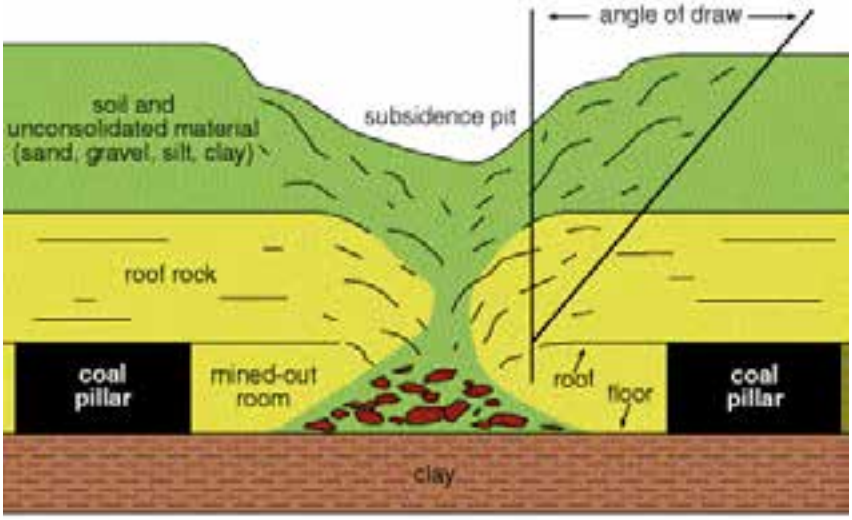
Unconsolidated Aquifer Systems	Organic Soils	Evaporite and Carbonate Rocks

Source*:* U.S. Geological Survey, *Ground Water and the Rural Homeowner, Pamphlet, 1982*

Overall, subsidence is not a very well-known hazard in most parts of Michigan, although it occurs with some regularity in parts of the state that have experienced past underground mining activity. The impacts of subsidence in Michigan tend to be limited in scope to individual sites and structures. Unlike some other areas in the country, such as Illinois, Ohio, Kentucky, West Virginia, Florida, Louisiana, and Pennsylvania, where subsidence is a serious concern, Michigan does not devote a great deal of state resources to the problem. Subsidence simply does not have the widespread impact potential of other natural and technological hazards that are prevalent in the state.

Underground mining has, in some respects, proved to be a double-edged sword for Michigan. On the one hand, it has fueled tremendous economic growth in many parts of the state, providing hundreds of thousands of jobs through direct mining or related industrial production activities. Mining helped put Michigan on the map as a world economic power, and even today it continues to be a major economic activity in some areas of the state. On the other hand, underground mining has also left a legacy of subsidence or threat of subsidence in some parts of Michigan. Old abandoned mines eventually begin to collapse under their own weight or human neglect, and oftentimes they swallow up whatever is built upon them. The following pictures show typical mine subsidence cross sections.

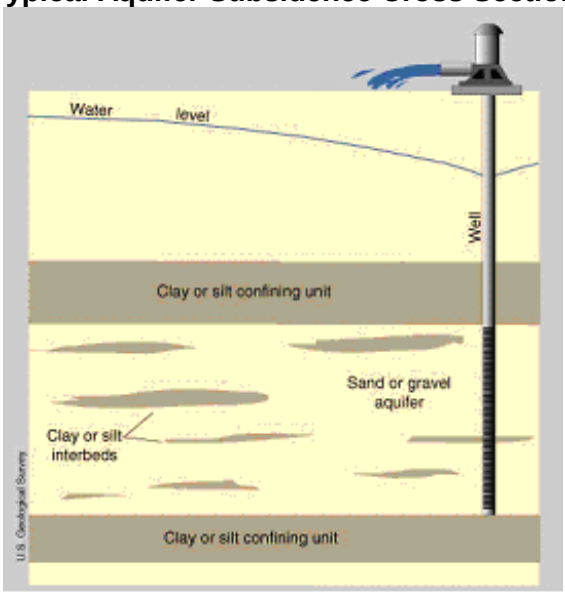
Typical Mine Subsidence Cross Section



Diagrammatic cross section of typical subsidence resulting from mine-roof collapse. No scale implied.

Source: State of Ohio, Department of Natural Resources web page

Typical Aquifer Subsidence Cross Section



Source: U.S. Geological Survey

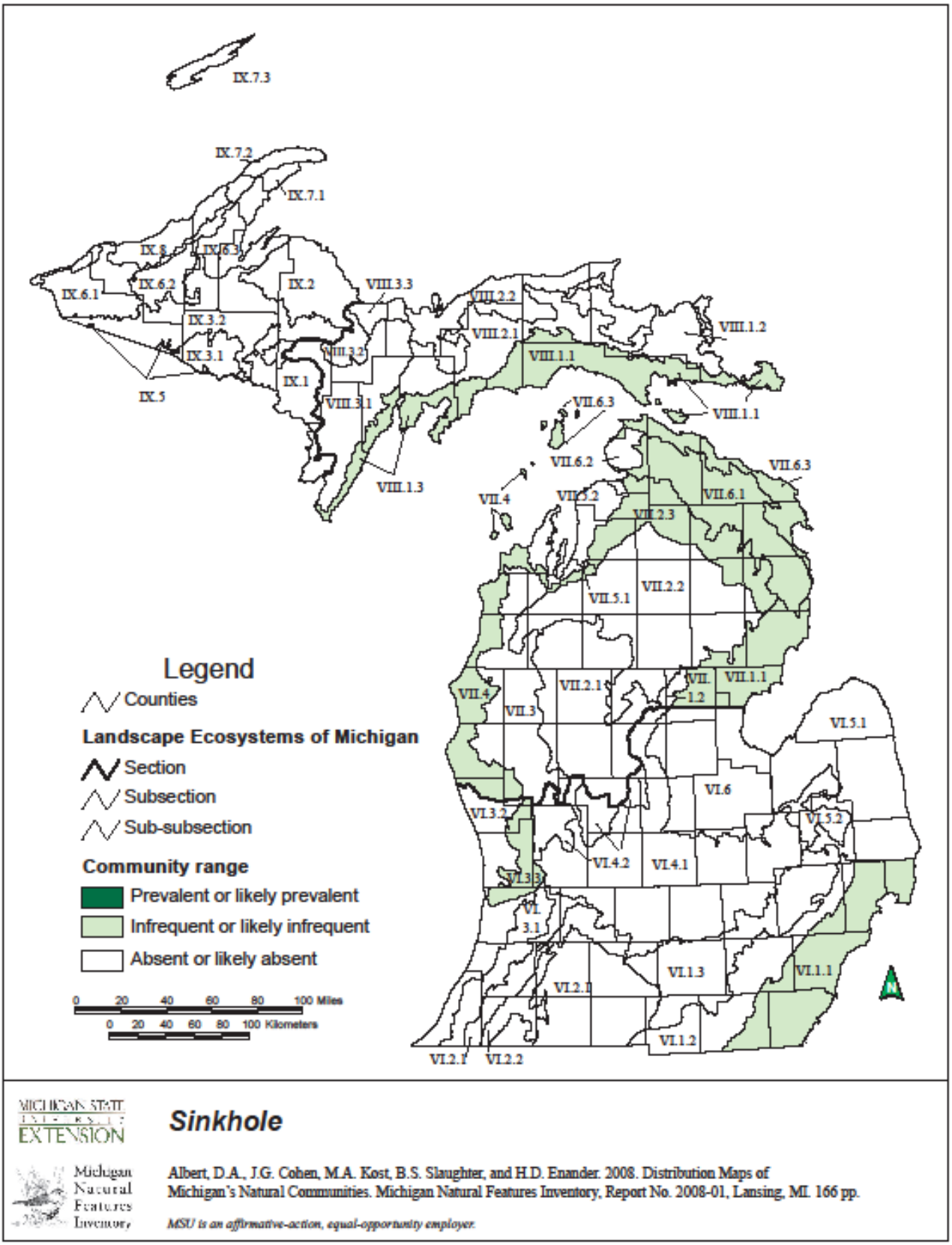
In some areas where ground-water pumping has caused subsidence, the subsidence has been stopped by switching from ground-water to surface-water supplies. If surface water is not available, then other means must be taken to reduce subsidence. Possible measures include reducing water use and determining locations for pumping and artificial recharge that will minimize subsidence. Optimization models, coupled with ground-water flow models, can be used to develop such strategies. The picture above shows a typical aquifer-related subsidence cross section.

Because subsidence tends to be a more sporadic hazard, and because it poses a greater hazard to property than to life, it does not receive much attention from government agencies or the public. Other natural hazards, such as tornadoes, floods and severe storms receive much more attention because of their more widespread and severe impacts. However, subsidence will continue to be a hazard that a segment of the Michigan population will have to deal with in the future. Major incidents that lead to catastrophic damage are nearly unknown in Michigan, but smaller incidents occur with some regularity in old mining areas. Overall, about four moderate incidents per decade have been noted.

Probably the most effective way to mitigate subsidence hazards is through community education and awareness. Local officials in subsidence-prone areas need to be aware of their community's potential vulnerability to subsidence, and that awareness needs to be communicated to the public. Communities that have experienced mineral and water mining activity in the past, or that have ongoing mining operations, should conduct a thorough investigation of potential subsidence sites as part of their community's hazard analysis process. More often than not, local records of mining activity are the best (and sometimes only) source of information on the nature and potential extent of the problem. Local officials can use that information to make informed community development decisions so as to avoid, to the extent possible, areas potentially vulnerable to subsidence.

Ideally, information about the locations and subsurface conditions of all mines in an area would be found, and testing or inspection could then determine their stability and safety. However, the information that does exist has no guarantee of being comprehensive, and since many mines exist on private property, the owners of that property often have an interest in not allowing any mine details to be publicized (lest the information cause trespassers to be attracted to their property). MSP/EMHSD learned about valuable information that had been collected on this topic through an academic research process, but the information was not available to the general public. The information had been provided to the relevant counties as a part of their local hazard analysis process, and it was reported that the same type of information was also known to local Mine Inspectors. The best resource to consult for each local area is probably the relevant Mine Inspector for that area. Please refer to the list available at http://www.mg.mtu.edu/mine_inspectors.htm.

Map of Michigan Sinkhole Risks



Source: MSU Extension website http://mnfi.anr.msu.edu/communities/community.cfm?id=10707

Impact on the Public

Although some incidents may cause private property damage and casualties, others may affect roadways or other public infrastructure, and thus cause a more general impact on the population of an area. (Please refer to the infrastructure failures subsection.)

Impact on Public Confidence in State Governance

The public may be prone to overestimate the amount of knowledge possessed by State government regarding areas and specific locations in which historic mines have existed. Subsidence events that involve damage to infrastructure or roadways may be attributed to poor maintenance or funding, rather than to the actual cause of subsidence that was responsible. Uncertainty about the extent of risk from subsidence may cause collective dissatisfaction with the area in which the hazard is present (or perceived to be present), and (at an extreme) may lower property values and cause or exacerbate emigration from the area.

Impact on Responders

Special hazards may be present in old mines or ground subsidence areas, which may present a risk of further collapses during emergency response. Areas that involve deep spaces, into which personnel and equipment may fall, necessarily entail a more complicated and dangerous situation for responders. Old mining tunnels may also contain toxic gases (as referred to in the oil and gas well subsections of this document).

Impact on the Environment

Environmental impacts stemming from subsidence are somewhat similar to those caused by an earthquake. Changes in an area's landscape, wildlife habitat and the natural ecosystem can all result from a sudden depression in the Earth's surface. In a severe event, infrastructure may be damaged and could release toxins into the air, soil, or waterways.

Significant Subsidence Incidents

Fortunately, Michigan has not had a catastrophic subsidence incident that involved death, injury or widespread property damage. However, smaller subsidence incidents have occurred that involved a single site or structure. The following incidents led to the implementation of reclamation projects designed to mitigate subsidence impacts. (Pertinent out-of-state incidents are also discussed.)

Various dates - U.S. Coastal States

In Florida, Louisiana, and some other coastal states, subsidence occurs with regularity, but for different reasons than it occurs in Michigan and other mining states. In Florida, subsidence is caused primarily by reductions in the water table caused by land development and groundwater withdrawal. Florida's cavernous limestone geology also plays a major role in its subsidence problem. A good example of that problem occurred on May 8-9, 1981 in Winter Park, Florida, when land collapsed, over a 36-hour period, into a sinkhole 324 feet wide and 100 feet deep. The collapse was caused in part by a prevailing drought. Damage was estimated at over $2 million and included a house, several cars, portions of several businesses, streets, and a municipal swimming pool. In Louisiana, subsidence is usually the result of a combination of oil and gas extraction, salt-water intrusion, and soil consolidation. Other coastal states face similar subsidence problems.

October 1984 - Jackson County

In October 1984, the abandoned Andrews Street Coal Mine in Jackson County partially collapsed, causing a detached garage, driveway and vehicle at a residence to collapse into a shallow sinkhole. A $12,000 emergency reclamation project was instituted in that subsidence incident.

October 1985 - Huron County

In October 1985, a subsidence incident occurred in Huron County that resulted in a sinkhole that swallowed up a portion of roadway. A $15,000 emergency reclamation project was instituted to mitigate the cause of the collapse.

May 1987 - Saginaw County

In May 1987, a subsidence incident in Saginaw County caused an attached garage and breezeway on a house to drop down several inches, damaging both structures. A $35,000 emergency reclamation project helped to mitigate the threat of future subsidence at that site.

March 1995 - Guernsey County, Ohio

In some other states around the country, subsidence has been a much more significant problem. For example, coal mining states such as Illinois, Kentucky, West Virginia, and Pennsylvania have large areas that are vulnerable to mine subsidence. In our neighboring state of Ohio, mine subsidence led to the collapse of a portion of Interstate 70 in Guernsey County in March 1995. That subsidence incident and the ensuing repair work closed the eastbound and westbound lanes of I-70 (a major national east-west highway) for several months, and final repair costs were $3.8 million. Fortunately, no deaths or injuries occurred as a result of the roadway collapse.

June 1999 - Philadelphia, Pennsylvania

Another dimension of the subsidence problem came to light in early June 1999 in Philadelphia, Pennsylvania, when several rowhouses were evacuated and torn down because they were sinking into the ground and in danger of collapsing. The homes had been built in the 1920s on old creek beds filled with a 21-foot layer of ash and cinders. Over time, the ground under the homes had slowly subsided, but then accelerated to the point where structural collapse was a real possibility. Officials suspect that sewer work done in the area in 1996 may have exacerbated and accelerated the problem. State assistance was provided to the evacuated homeowners to help offset the loss of their homes. (Homeowners insurance policies generally do not cover subsidence-related problems.) In 1987, the City had paid another $20 million to reimburse losses to 1,000 homeowners whose homes were also found to be sinking into the ground.

Although this problem occurred in Pennsylvania, it has implications for Michigan and other states. Building homes and businesses over streambeds and floodplains was a standard practice across the country during the early part of the 20th century. Home construction was lightly regulated during that period, and the regulations that were enforced were generally targeted more toward fire safety or other health and sanitation concerns. Hundreds of thousands of homes and

businesses across the country may have been built in these unstable areas. Local building records are often incomplete or non-existent, so the situation may not become evident until a home or business begins to sink into the ground.

June 1999 - Milan (Monroe County)

On June 29, 1999 northbound traffic on U.S.-23 at Milan was diverted for approximately 10 hours after the pavement sank eight inches over a 30-foot stretch of highway. The subsidence and traffic diversion caused traffic to back up for several miles throughout the day. Although a definitive cause of the subsidence was not established, officials believe a leaking storm sewer may have contributed to the problem.

July 1999 - Iron Mountain (Dickinson County)

On July 27, 1999 an abandoned mineshaft in Iron Mountain (Dickinson County) caved in, exposing a 50-foot diameter by 1,600-foot deep shaft. The cave-in occurred directly adjacent to the Cornish Pumping Engine and Mining Museum, a popular tourist attraction in the downtown area. The structure was in danger of collapsing into the opening until temporary stabilization measures were taken. Officials were also concerned that further subsidence could have damaged nearby infrastructure, including a roadway. Because the cave-in posed a significant threat to public safety, a Governor's Emergency Declaration was granted to provide state assistance in securing the site and permanently capping the opening.

February 2000 – Detroit (Wayne County)

On February 9, 2000 a 15-foot sinkhole opened up on Seneca near Mack, on Detroit's east side. The sinkhole swallowed up a half-ton pickup truck. Fortunately, the truck's two occupants escaped serious injury. Officials believe a leaking underground pipe may have caused the subsidence.

April 2001 – Gaastra (Iron County)

On April 19, 2001 the City of Gaastra in Iron County sustained a cave-in of 3,360 cubic yards of soil at the abandoned Baltic Mine Pit in the city, leaving four feet of ground between the mine pit and the City's main (and only) sewer line to the wastewater treatment plant. (When the sewer line was installed in 1984, there were 100 feet of ground between the line and the edge of the pit. From 1984 to 2001, the annual recession rate at the site was nearly six feet per year.) The April 2001 cave-in was the second major subsidence incident at that site in recent months, following on the heels of a similar cave-in that occurred in August 2000. Local and state officials feared that another subsidence incident at the site could cause the sewer line to break, resulting in significant public health, safety and environmental concerns due to lack of sewer service, contamination of nearby water wells, and contamination of the Iron River. In addition, a major subsidence incident could also have caused a partial collapse of County Road 424 (which runs parallel to the sewer line), negatively impacting the area's residents and tourist-oriented businesses.

To mitigate further damage to the threatened sewer line, the City of Gaastra applied for a Hazard Mitigation Grant Program (HMGP) grant to relocate the line outside the subsidence area. Work on that project was successfully completed, including appropriate steps to stabilize the roadway shoulder and prevent further ground collapse.

March 2004 - Detroit (Wayne County)

On March 25, 2004 a sinkhole about 20 feet wide and 14 feet deep opened in the westbound lanes of Six Mile Road. It was determined that water main work done in the area in the previous six months had not been completed properly. Leaking water apparently washed away the soil underneath and created the sinkhole.

August 2004 - Sterling Heights (Macomb County)

On August 22, 2004 a sewer line break caused a section of 15 Mile Road in Sterling Heights to collapse, prompting residents in six homes to evacuate and the street to close for several weeks. After the break, two sinkholes formed and eventually merged, forming one hole 150 long and 45 feet wide There were about 15 homes in the area that lost water service for several hours and around 1,000 Detroit Edison customers lost power because utility poles were being removed for excavations to reach the sewer. About 7 million gallons of raw sewage was diverted daily from the collapsed sewer into the Mount Clemens sewage treatment plant to prevent wastewater from entering basements or polluting county drains and streams. Eight families living on the edge of the sinkhole tried to claim $1 million each for damages to their homes and for health reasons. No outcome had been reached at the time of this writing.

May 20, 2010 – Detroit (Wayne County)

A sinkhole large enough to swallow a car appeared on May 20, 2010 in downtown Detroit and closed West Lafayette Street between Shelby and Griswald. The street began to crumble away after crews working to demolish the historic Lafayette Building punctured a water line.

October 4, 2010 – Stephenson (Menominee County)

A 600-foot long crevice suddenly opened up—in some places only a foot wide and a few inches deep, but in other places more than 2 feet wide and 5 feet deep. Fortunately, this took place in an undeveloped area on private property, where no injuries were caused and no damage to built property or physical infrastructure was reported. Vibrations were felt by nearly residents, who were uncertain whether they were feeling the effects of explosive blasting or some other force. Although this event resulted in no harm, the executive director of the Delta Conservation District (in Gladstone) was quoted in newspaper reports as stating that this type of phenomenon is not unusual in the Upper Peninsula. He stated that the cause of the fissure sounded like it was the result of rock fracturing below the surface—that areas containing fractured rock formations can result in fissures and sinkholes as the result of pressures generated by the annual freeze-thaw process (and that the same process could also form hills)

January 21, 2011 – Detroit (Wayne County)

A Detroit man was injured when the front end of his SUV went into a 10-foot-wide sinkhole caused by a water main break on Detroit's west side. The 52-year-old victim was taken to a local hospital, where he was treated for minor injuries. The sinkhole was on Pickford Street between Heyden and Vaughan.

August 18, 2011 – Detroit (Wayne County)

Another serious incident occurred in Detroit, this time on Beaubien between Chandler and Smith, when a partially collapsed sewer caused a massive sinkhole to appear in the street. An SUV driving over that part of the street was the last stress that the buckling pavement could take, and the car nosedived as the road collapsed downward, shattering a water main in the process and causing the sinkhole to completely fill with water. Two women and an infant were successfully rescued from the vehicle, and some area residents were without water as the main was being repaired.

March 23, 2011 – Ann Arbor (Washtenaw County)

A crack in a concrete retention system caused a 40 foot sinkhole to occur on March 23, 2011 in Ann Arbor, outside an underground parking structure construction site. The combination of the retention wall, the thawing of the ground and sandy soils could have caused an underground cavity behind the concrete retention system to bubble up vertically to open the hole. Two businesses were closed for the day after the ground opened in a shared parking lot used by both businesses.

January 18, 2014 – Detroit (Wayne County)

A gaping sinkhole appeared in East Jefferson Avenue at Randolph Street near the Renaissance Center. It was about 8 feet wide and several feet deep, in the north lane. Sometime overnight on Saturday night or Sunday morning, January 18-19, smaller road problems had expanded into this gaping hole. It is not known whether some cars suffered damage during its formation, but the area was soon cordoned off to be worked upon by repair crews.

Programs and Initiatives

Michigan Department of Environmental Quality, Office of Geological Survey

The Michigan Department of Environmental Quality, Office of Geological Survey (MDEQ/OGS), regulates metallic mining in Michigan. The OGS regulatory authority is granted under Parts 631, 635 and 637 of the Michigan Natural Resources and Environmental Protection Act, 1994 PA 451, as amended. The Office's activities include issuing permits for metallic mining operations, maintaining maps and records on mining areas, and regulating mine reclamation. In terms of mine subsidence, the OGS works with local officials and the Office of Surface Mining Reclamation and Enforcement (OSMRE), U.S. Department of the Interior, to mitigate coal mine subsidence problems through special projects aimed at properly sealing mine shafts and otherwise ensuring the structural integrity of underground coal mined areas.

Surface Mining Control and Reclamation Act

There is very limited state funding for mine subsidence mitigation. Therefore, most of the funding for such projects comes from the federal government. The primary federal funding source is the Abandoned Mine Lands (AML) Reclamation Fund in the Surface Mining Control and Reclamation Act (SMCRA), P.L. 95-87, administered by the U.S. Department of Interior's OSMRE. AML funds are derived through a tax on coal production targeted at reclaiming land and water resources adversely affected by pre-1977 coal mining. These funds can also be used for mine subsidence mitigation measures and salt sealing, which Michigan has done on numerous occasions. Normally, priority is given to those emergency projects that involve mine lands that present an immediate danger to the public health, safety or general welfare. Typically, such emergencies include landslides near homes and across roads, subsidence occurring under houses and public buildings, mine and coal waste fires, and open mineshafts discovered near populated areas.

Subsidence Insurance

Unlike states such as Illinois, Ohio, Pennsylvania, Kentucky and West Virginia, which have state insurance programs for homes and businesses in subsidence-prone areas, Michigan does not have such a program. As a result, home and business owners and communities that are affected by subsidence must rely on whatever private insurance payments they can collect for subsidence-related damages, or they must pay for damages out-of-pocket. (Subsidence-related damage is generally not covered under a standard homeowner's insurance policy.)

National Association of Abandoned Mine Land Programs

Michigan is a member of the National Association of Abandoned Mine Land Programs, a national advocacy group that provides a forum and clearinghouse for addressing issues and problems pertaining to mine subsidence and reclamation. Michigan's participation is beneficial in that it gains tremendous knowledge of the experiences of other states in reclaiming mine sites and mitigating subsidence. In addition, Michigan also gains knowledge about current reclamation and mitigation technologies that could be applied to problem areas in the state.

Local Mine Inspectors

Information about the locations and subsurface conditions of mines has no guarantee of being comprehensive in an area, and since many mines exist on private property, the owners of that property often have an interest in not allowing any mine details to be publicized (lest the information cause trespassers to be attracted to their property). However, known mines are subject to inspection, to determine their stability and safety. Valuable information is available for certain counties and their local Mine Inspectors. Locally specific information should be sought from the relevant Mine Inspector for that area. Please refer to the list available at http://www.mg.mtu.edu/mine_inspectors.htm.

Hazard Mitigation Alternatives for Subsidence

- Identifying and mapping old mining areas and geologically unstable terrain, and limiting or preventing development in high-risk areas.
- Filling or buttressing subterranean open spaces (such as abandoned mines) to discourage their collapse.
- Hydrological monitoring of groundwater levels in subsidence-prone areas.
- Insurance coverage for subsidence hazards.
- Real estate disclosure laws.

Tie-in with Local Hazard Mitigation Planning

Because many means of implementing mitigation actions occur through local activities, this updated MHMP places additional emphasis on the coordination of State-level planning and initiatives with those taking place at the local level. This takes two forms:

1. The provision of guidance, encouragement, and incentives to local governments by the State, to promote local plan development, and
2. The consideration of information contained in local hazard mitigation plans when developing State plans and mitigation priorities.

Regarding the first type of State-local planning coordination, MSP guidance has included the "Local Hazard Mitigation Planning Workbook" (EMD-PUB 207), which is currently being updated for release by 2015. For the second type of State-local planning coordination, a section later in this plan summarizes hazard priority information as it has been reported in local hazard mitigation plans. Here, it will merely be noted that subsidence was identified as one of the most significant hazards in the local hazard mitigation plans for Baraga, Dickinson, and Houghton counties.

CELESTIAL IMPACT

An impact or threatened impact from a meteorite, asteroid, comet, satellite, space vehicle, space debris, solar storms, or similar phenomena that may cause physical damages or other disruptions.

Hazard Description

The celestial impact hazard primarily concerns the effects of large forces (from objects or energy) upon the Earth or its atmosphere. Most such forces are extraterrestrial in origin—**meteors** (which burn up in the atmosphere) or **meteorites** (which impact physically upon the ground) that were originally **asteroids** or **comets** from elsewhere in the solar system. It must be noted that even in cases where no meteorite actually strikes the ground, the explosive energies from the meteor's impact upon the many layers of atmosphere can create an intense heat and blast area, along with very strong winds, and can release more energy than even the largest nuclear bombs. Massive or fast moving bodies that impact upon either the ground, the oceans, or the atmosphere can cause widespread destruction and disruption of both human and natural systems, including secondary hazards such as earthquakes, volcanoes, tsunamis, and severe winds, although events of that magnitude are extremely rare.

Much more common is the flare-up of energy and charged particles that are emitted and ejected by the Sun and impact upon the Earth's atmosphere. These **solar geomagnetic storms** (also known as **space weather**) can cause widespread failures of important satellite, electronic, communication, navigation, guidance and electric power systems—which have all formed a very important part of our modern technology and lifestyles. Because of the amount and complexity of information concerning the potential impacts from space objects, a great deal of this section has been devoted to an explanation and analysis of that hazard. However, it is important to note at the outset that the solar storm hazard is far more likely in the near term to cause disruptive effects, large economic impacts, and risks to human life. The smaller amount of text dedicated to space weather in this document should not mislead readers into a sense that it is considered less important, or that it is expected to cause less impact in the near future. Rather, the conclusion of the analysis presented here is that the effects of space weather have already had, and are much more likely to have, strong impacts upon Michigan within the normal historical timeframe that is typical for this type of plan. By contrast, the extensive discussion of impacting physical objects is given primarily to be "on the safe side" so that readers and emergency managers can be well-informed in the unlikely event that a very serious incident does occur, or threaten to occur.

Although it has been estimated that a major impact from a physical body upon the Earth occurs approximately once per century, recent discoveries (and the fact that much more of the Earth has been covered by human developments within the recent past) have caused increasing concern over this hazard. Although most meteorites would be expected to strike an ocean rather than a continent, the effects of a large enough ocean strike can still be widely damaging, through resulting tsunami and seismic activities.

An important type of celestial impact involves the interference or disruption of modern electronic and communications systems, including those upon which our modern aviation networks rely. Solar flares and storms (also known as "space weather") are highly relevant for their potential impacts and possible disruption of these complex modern communication systems—satellites, television, radio, GPS, power supply networks, and the extensive human and technological infrastructure that relies upon those communication and utility networks.

Extensive evidence of previous celestial impacts upon Earth has been discovered, including evidence of a historic crater site located in southwest Michigan, but the vast majority of historical Earth impacts have had their evidence erased from normal observation by the ongoing geological processes that take place over time. Even the largest of impact sites would no longer be evident to normal observation after a period of about 200 million years (usually much, much less). Such an amount of time is less than 5% of the Earth's overall age, but it has been found that impacts used to occur much more frequently during the earlier periods in Earth's history (i.e. nearer to the period of planetary formation) than they do in recent geological periods. Clearer evidence of the many historical impacts can be seen on other celestial bodies that are less geologically active, such as Earth's own Moon.

Asteroids

Most asteroids are located in the main asteroid belt and have well-defined orbits there between 200 and 310 million miles from the Sun, but thousands of asteroids also exist in other parts of the solar system. There are groups of "Trojan" asteroids that share an orbit with Jupiter, for example, located 60 degrees both ahead of and behind that planet itself while going around the Sun. Asteroids that have paths which cross over Earth's orbit are classified as

Near-Earth Objects (NEOs), and are called Apollo asteroids. Two other types of NEOs are Amor asteroids, which approach the Earth's orbit from positions outside of it, and Aten asteroids, which approach the Earth's orbit from the direction of the Sun. As of January 2009, there were 6,021 NEOs identified, of which 1,026 were classified as posing the possibility of threat (having the potential to come within 466,000 miles of the Earth's orbit; by comparison, the average distance of the moon is 238,900 miles). The typical asteroid would impact upon the Earth at an angle of 45 degrees and a speed of 10 miles per second, but a wide variation around this average is possible.

Comets

More than 99% of all meteorites come from asteroids, but some comet impacts have also been confirmed (9 are known, constituting less than 0.03% of all meteorites). The main difference between comets and asteroids is that comets tend to have elliptical orbits that carry them out beyond the "nebular frost line" (located in the main asteroid belt, about 250 million miles from the Sun) and thus their composition includes a substantial amount of icy and frozen matter. Comets usually lose about 0.1% of this matter each time they pass by the sun, due to the effects of warming and the pressure of solar radiation, and this matter trails behind them in their long "tails," which include charged particles (with associated magnetic fields) and can stretch across many tens of millions of miles of space. Where such tails cross the Earth's orbit, this matter (typically small and harmless to us) generates sometimes spectacular "meteor showers" as it periodically burns up in the Earth's atmosphere at regular times during the year. After a certain number of orbits, however, the comet simply breaks apart. Even if less dense than the average asteroid, a comet's heavy nucleus can be sizeable (from several hundred meters to over 40km in diameter), and a comet impact upon the Earth would typically occur at a speed of 31 miles per second—about three times as fast as the average asteroid, with a proportionally larger momentum of destructive energy if the amount of mass is the same. (It is worth noting here that the maximum impact upon the Earth for any object orbiting the Sun would be no more than 44.5 miles per second—160,000 miles per hour.)

Comets are classifiable by their orbital period, with long period comets taking more than 200 years to travel around the Sun, and short period comets taking less than that. The short period comets are further subdivided into Halley-type comets with orbital periods between 30 and 200 years, and Jupiter-type comets with orbital periods of less than 30 years. Long period comets originate in the farthest reaches of the Solar System (the Oort Cloud) and approach the Sun and Earth from every direction, while short period comets originate from the "Kuiper Belt" that exists beyond Neptune and is approximately in the same plane as all of the major planets. Short period comets thus would approach us from more predictable, shallow angles. The comet only begins to glow, though, when it approaches to within 3 and 5 Earth-distances from the Sun (3 to 5 astronomical units). Since short-period comets tend to last for only a matter of hundreds or perhaps thousands of orbits, their number seems to be replenished by a reservoir in our solar system (whose orbits eventually become shifted by gravitational perturbations). The Oort Cloud probably contains about a trillion comets, but most of these remain so far away that we remain unaware of them. The Kuiper Belt contains billions of comets, and the average diameter of one that comes near to the Sun is about 10 km.

If advance notice of an approaching meteor, asteroid, or comet is available, then widespread alerts might be prompted by this information, much as the explosive breakup of the Space Shuttle Columbia in 2003 had required warnings and alerts across multiple southwestern states, due to the possibility of persons and property being affected by falling debris. (See the event descriptions that appear later in this chapter.) In the case of the Cosmos 954 and Space Shuttle incidents, such debris needed special handling, both for purposes of investigation and out of concern for personal safety, since some of it could have contained hazardous substances. The threat of a celestial impact could be much more dangerous and far-reaching. One clear example of the potential damage was seen in the impact of the comet Shoemaker-Levy 9 on the planet Jupiter, in 1994, which resulted in blasts that were estimated as the equivalent of ten million megatons of explosives. In comparison, the 1979 Mount St. Helens eruption was roughly 5 megatons, and the 1885 Krakatoa eruption in Indonesia was about 100 megatons. Following the Shoemaker-Levy comet impact, Congress authorized new research to analyze this type of celestial impact hazard.

Space Weather

The Sun does not "burn" in the sense that we usually experience that common heat-generating process on Earth, but rather emits huge amounts of energy from the continuous processes of nuclear fusion that take place in the Sun's core. The gravitational pressures of the Sun's enormous mass, pulling toward itself, are thus generally offset by outward pressures from the fusion processes that take place at its core. Enormous amounts of energy are radiated from the Sun, including the spectrum of electromagnetic waves up through gamma wave frequencies. These include infrared (heat) radiation, ultraviolet, all colors of visible light, x-rays, microwaves, and radio waves. The intensity of these forms of

radiation varies, and gamma waves are normally only emitted during solar flare events (to be explained shortly). It should also be understood that in the midst of all these solar interactions of matter and energy are powerful magnetic forces, which also affect the distribution of heat energy in and around the Sun and sometimes cause cooler areas, called **sunspots**, to form for a while, readily visible even with crude forms of observational equipment. (Although an observer should never look directly at the Sun, a pinprick of solar light projected onto a surface provides one basic means of seeing a Solar image). The relatively low temperatures of sunspot areas, however, are coupled with a rise in energy above the Sun's surface. **Solar prominences** are arches of plasma that soar above the Sun's surface, in a pattern that is itself shaped by the powerful magnetic fields present. In some cases, these magnetic fields have become too twisted to maintain such forces within these ordinary patterns, and a **solar flare** is generated, which releases a huge amount of energy from the Sun. Normally, a **solar wind** exists in the form of milder pressures exerted by emitted photons, ions, and other particles that flow outward from the Sun until they are eventually halted (beyond the orbit of Neptune, at an area called the heliopause) by the pressure of interstellar gases. Within the realm of the Sun's planets, however, the solar wind is an ongoing feature of the space environment, constantly sending energy and charged particles outward.

Space weather is a term that denotes the impacts of the Sun's activity upon the bodies within this sphere inside the heliopause, including our own Earth. As with the weather on Earth, there are some clear patterns that are exhibited by space weather. More turbulent space weather is produced during times when more sunspots are present (called a solar maximum), and space weather is calm during times when sunspots are rare and small (or not even seen to be present at all, called a solar minimum). A **sunspot cycle** exists, in which sunspot activity regularly shifts between a minimum and maximum level. As with our Earthly seasons, however, it cannot be known in advance exactly how turbulent or calm things will be at a given moment during the sunspot cycle—only that calmer periods regularly give way to more turbulent periods. As to the regularity of the sunspot cycle itself, although it has been found that the average amount of time between a solar minimum and a solar maximum is about 11 years, the actual length varies quite a bit within each cycle. The interval is sometimes as long as 15 years and sometimes as short as 7 years. In addition, it has been observed that long periods can occur with little or no sunspot activity. The "Maunder minimum," which occurred between the years 1645 and 1715, is the primary example of such long-term variation from the normal cycle, but it is not yet known what caused it, or when it might recur. The Earth's atmosphere serves as a shield for us against many types of particles and radiation zipping across space, and Earth also has a **magnetosphere** that similarly provides protection against most of the charged particles traveling through space. There are some weak spots in the Earth's magnetic field, however, that exist near its two magnetic poles and allow many ions to penetrate, where they collide with atoms in the Earth's upper atmosphere and glow to produce the beautiful auroras in the skies of the arctic regions of the north and south. In addition, the Earth is surrounded by "belts" of charged particles (called Van Allen belts) which are hazardous to spacecraft and astronauts. These are known and predictable conditions of calm space weather, however, and the actual hazard is the turbulence that is generated by large solar flares, causing problems with radio communications, damage to satellites, and even disruptions in power delivery networks on the Earth. Currently, as of early 2012, sunspot cycle number 24 is proceeding, from a solar minimum that was reached in December 2008 and is projected to transition to a solar maximum by early 2013 (a relatively short cycle).

Another type of solar disturbance is a **coronal mass ejection** (CME), in which built-up pressures cause a sudden burst in gases and magnetic fields at tremendous speeds, with impacts that reach far across interplanetary space. Like solar flares, CME events are a cause of geomagnetic storm events on Earth (usually 1 to 4 days after the solar event), and they occur more frequently during periods with more sunspots. One of the additional effects of space weather involves increased exposure to ionizing radiation (e.g. x-rays), especially among those in aircraft at high altitudes and along polar flight paths. Extra costs, in fuel and delays, are imposed upon airlines during periods of harmful space weather.

Hazard Analysis

A couple of scales have been developed to numerically summarize the extent of risk associated with extraterrestrial celestial bodies, such as comets, asteroids, and meteoroids. One scale is called the Palermo scale, but since that is tricky to interpret, the Torino Scale has instead been featured in media reports since its initial presentation at a United Nations conference in 1995, and it was adopted by the International Astronomical Union in 1999. Both scales take into consideration the amount of destructive energy that an impact could cause, and the probability of such an impact occurring. It is common for newly discovered objects to have their initial classifications on these scales subsequently downgraded, as additional information is collected that more precisely defines the exact path of the object. In other words, an object that is initially classified as having the potential for impact, and thus being worthy of closer study, is

often later reclassified as additional information reveals that little or no significant impact potential exists. The lower numbers on the scale should not be interpreted as indicating any particular concern, and in the previous 15 years, only one object (99942 Apophis) had temporarily been classified as high as a 4 on the Torino scale. Being an asteroid large enough to cause regional devastation if it struck, Apophis had initially been estimated to have a 1 in 45,000 chance of striking the Earth on April 13, 2036, but as more information was obtained about its trajectory, that estimate was downgraded to only a 4 in 1 million probability. Although the asteroid's approach will be spectacular to observe, it is predicted to come as close as 18,300 miles away from the Earth's surface as it passes. (In Celestial terms, this is a very near miss, because that distance is smaller than the circumference of the Earth.)

The official explanation of Torino Scale ratings are provided below. In addition to numerical categories from 0 to 10, the scale is also color-coded in five categories, from white to red.

THE TORINO IMPACT HAZARD SCALE:

No Hazard (White Zone)

0: The likelihood of a collision is zero, or is so low as to be effectively zero. Also applies to small objects such as meteors and bodies that burn up in the atmosphere as well as infrequent meteorite falls that rarely cause damage.

Normal (Green Zone)

1: A routine discovery in which a pass near the Earth is predicted that poses no unusual level of danger. Current calculations show the chance of collision is extremely unlikely with no cause for public attention or public concern. New telescopic observations very likely will lead to re-assignment to Level 0.

Meriting Attention by Astronomers (Yellow Zone)

2: A discovery, which may become routine with expanded searches, of an object making a somewhat close but not highly unusual pass near the Earth. While meriting attention by astronomers, there is no cause for public attention or public concern as an actual collision is very unlikely. New telescopic observations very likely will lead to re-assignment to Level 0.

3: A close encounter, meriting attention by astronomers. Current calculations give a 1% or greater chance of collision capable of localized destruction. Most likely, new telescopic observations will lead to re-assignment to Level 0. Attention by public and by public officials is merited if the encounter is less than a decade away.

4: A close encounter, meriting attention by astronomers. Current calculations give a 1% or greater chance of collision capable of regional devastation. Most likely, new telescopic observations will lead to re-assignment to Level 0. Attention by public and by public officials is merited if the encounter is less than a decade away.

Threatening (Orange Zone)

5: A close encounter posing a serious but still uncertain threat of regional devastation. Critical attention by astronomers is needed to determine conclusively whether or not a collision will occur. If the encounter is less than a decade away, governmental contingency planning may be warranted.

6: A close encounter by a large object posing a serious but still uncertain threat of a global catastrophe. Critical attention by astronomers is needed to determine conclusively whether or not a collision will occur. If the encounter is less than three decades away, governmental contingency planning may be warranted.

7: A very close encounter by a large object, which if occurring this century, poses an unprecedented but still uncertain threat of a global catastrophe. For such a threat in this century, international contingency planning is warranted, especially to determine urgently and conclusively whether or not a collision will occur.

Certain Collisions (Red Zone)

8: A collision is certain, capable of causing localized destruction for an impact over land or possibly a tsunami if close offshore. Such events occur on average between once per 50 years and once per several 1000 years.

9: A collision is certain, capable of causing unprecedented regional devastation for a land impact or the threat of a major tsunami for an ocean impact. Such events occur on average between once per 10,000 years and once per 100,000 years.

10: A collision is certain, capable of causing global climatic catastrophe that may threaten the future of civilization as we know it, whether impacting land or ocean. Such events occur on average once per 100,000 years, or less often.

Note: This is the Torino Scale as revised in 2005. A graphic of the Torino Scale is also available at http://neo.jpl.nasa.gov/images/torino_scale.jpg .

The Palermo Technical Impact Hazard Scale is a bit different, with values less than -2 reflecting events for which no consequences are likely, values between -2 and 0 indicating situations that merit careful monitoring, and values above

zero indicating situations that merit some level of concern. This document presents only the Torino scale in its entirety, since that scale was developed for general public informational uses.

About 40,000 to 60,000 tons of extraterrestrial material falls onto the Earth each year, but most of it is mere dust. Larger materials fall during regular cycles called meteor showers, but again most of it is small enough to harmlessly burn up (through ablation) as it hits the Earth's atmosphere at high speeds (typically about 67,000 mph). During meteor showers, the material is typically leftover debris from comets that had crossed the Earth's orbit, and most such material is very small and harmless to us. Material that does survive ablation to strike the Earth's surface lands in random locations, and since 70% of the Earth's surface is water, these meteorites mostly go unnoticed by ordinary people. The risk to Michigan is calculable in general terms, by considering the proportion of the Earth's total surface area that is occupied by Michigan's land area. This is approximately 2.9×10^{-4}, or 0.00029. The frequency of global impact events can then be multiplied by this factor to estimate the frequency of impact events directly upon Michigan's land area. This results in the following estimates, on average, for different sizes of impacts upon Michigan's land itself:

- About 1 to 5 impacts per year that are larger than 100g (golf-ball size) – This may kill an individual that is struck, but since most space is not occupied by a person at any particular moment, such a thing is exceptionally rare, and there have only been a couple of confirmed meteorite injuries worldwide. Instead, such incidents are more likely to simply cause limited property damage to a car or home, although their appearance in the sky can appear impressive and be accompanied by a sonic boom. (Example: the Washtenaw County strike of 1997.)
- About one impact per century involving an object of more than 100kg (220 pounds), and about one impact every 1700 years involving an object of more than 1000kg (about 2200 pounds) – These types of events would result in loud sounds and bright flare-ups in the sky, leaving a field of fragments strewn across an area that is miles across, but actual damages are likely to be only moderate unless a dense urban area or critical facility happens to be struck. (Example: the Park Forest, IL event of 2003.)
- About one impact every 350,000 years involving an object of more than 100,000kg (about 220,000 pounds) – This is the type of impact that resembles an atomic blast, exploding brightly in the sky and producing a very strong blast wave and severe winds that would cause extensive building damages and collapse at ground level, and would flatten forest lands. (Example: the Tunguska, USSR event of 1908.)

Although that last type of event is so rare that it need not be of general concern for Michigan, the probability of such an event affecting some part of the U.S. and potentially causing a national emergency is a bit larger, but still remote. It is most probable that the next such event will occur elsewhere in the world (on the order of about 1 event per century) and, although potentially devastating to that area, Michigan's role would probably only involve the voluntary donation of humanitarian aid to the disaster area. One foreseeable scenario could involve an asteroid impact in the ocean, which causes tsunami impacts upon the associated coastline of the U.S.—waves could be more than 100 feet high from the impact of an asteroid with a diameter of 1300 feet, although that scale of event would only be expected about once in 80,000 years. These types of large events—the kind that would actually form sizeable craters and cause catastrophic national or global impacts (including major seismic and volcanic effects and global cooling from gaseous effects and dust, smoke, and particulates deposited into the atmosphere)—are rare enough that no extensive description will be provided here—past events of that type are well-established in a geological timeframe but not in a human historical timeframe. (Reference will be made to such events primarily in the description of mitigation strategies.)

Since meteors flare up brightly in the sky, some persons have speculated about whether meteorites could then cause wildfires to start up. As it turns out, this is generally not the case. The flaring fireballs are caused by ablation, as the very fast meteors encounter the atmosphere and friction generates heat, but a great amount of material typically burns away in this process, followed by miles of additional falling before ground impact, during which time the contact with blowing air exerts a cooling effect. The vast majority of meteorites are actually cool when they strike the ground. It would take a very large impact to bring a degree of heat that is capable of igniting a forest fire, and impacts of that size are very rare. That type of rare, large impact would also tend to flatten forest lands at the same time, with blast pressure and wind effects that could offset much of the fire risk. A large (Tunguska-sized) event would cause forest fires, along with huge amounts of other damage, and it is conceivable that a smaller-sized (but still very rare) impact might cause wildfire ignition if there are already drought conditions present that have increased the natural wildfire risk. In general, wildfires will not be caused by meteorites, and there is no good evidence that any of Michigan's historic wildfires were of meteoritic origin.

Space weather can be very expensive for those who use or rely upon satellites. During a solar maximum, the Earth's upper atmosphere expands and increases the drag upon satellites within low orbits, which will then require boosting in order to remain aloft. Electronic circuits can malfunction and cause interruptions or complete losses in operational capacity. Space missions may also need to be delayed, in order to ensure their safety and success. Special design features may require additional expenses, to mitigate the effects of space weather. Communication disruptions can inhibit navigation and hinder the safe management of air and sea traffic. Electric currents are induced by the relative motion of magnetized material, and these can affect power supply and pipeline infrastructure, potentially causing weakening and damage in these systems as well as electronic malfunctions. Three space weather scales are in use by NOAA/NWS to summarize the intensity and potential impact of three different types of space weather effects. Each uses a 5-category classification scheme, and the three scales denote (1) geomagnetic storm intensity, on a G-scale, (2) solar radiation storms, on an S-scale, and (3) radio blackouts, on an R-scale. Weaker events are given a number of 1 on the scale, and extreme events are rated as a 5. In this document, selected material is summarized below. For more detailed information, please refer to the NOAA web site at http://www.swpc.noaa.gov/NOAAscales/.

NOAA Space Weather Scales

NOTE: Each type of space weather may occur separately. Descriptions of all three types of space weather warnings are here combined into one table merely to conserve space.

HF means high frequency (radio waves), but other radio frequencies may also be affected by these events. LF means low frequency (radio waves). F: refers to event frequency.

Category Labels	Geomagnetic Storms (effect & frequency)	Solar Radiation Storms (effect & frequency)	Radio Blackouts (effect & frequency)
Minor G1 S1 R1	G1 events can cause weak power grid fluctuations, minor impacts on satellite operations, effects on migratory animals, and widely visible auroras seen in Northern Michigan. F: about 900 days per solar cycle.	S1 events result in minor impacts on HF radio in polar regions. F: about 50 such events per solar cycle, each of which can last more than 1 day.	R1 events cause weak or minor degradation of HF radio communication on the sunlit side of Earth, and occasional loss of radio contact. LF navigation signals used by maritime and general aviation systems may be degraded for brief intervals. F: about 950 days per solar cycle.
Moderate G2 S2 R2	G2 events can cause high-latitude power systems to experience voltage alarms. Long-duration storms may cause transformer damage. Corrections to satellite orientation and orbital drag prediction may be required. HF radio propagation can fade at higher latitudes. Auroras may be visible throughout Michigan. F: about 360 days per solar cycle.	S2 events may expose persons in high-flying aircraft to an elevated radiation risk* in areas of high latitude. Infrequent single-event upsets of satellite operations are possible. Possible effects on HF propagation and navigation through polar regions. F: about 25 events per solar cycle, each of which can last more than 1 day.	R2 events cause a limited blackout of HF radio communications on the sunlit side of Earth, and loss of radio contact for tens of minutes. LF navigation signals may also be degraded for tens of minutes. F: about 300 days per solar cycle.
Strong G3 S3 R3	G3 events may require voltage corrections at power systems and may trigger false alarms on their protection devices. Satellite orientation problems may need correction. Increased atmospheric drag and component surface charging may occur. Intermittent LF radio navigation problems may occur. F: 130 days per solar cycle.	S3 events can expose persons in high-flying aircraft to a radiation risk* in areas of high latitude. Satellite operations may experience single-event upsets, imaging system noise, and slight solar panel inefficiencies. Degraded HF radio propagation in polar regions. Navigation position errors are likely. F: about 10 events per cycle (each can exceed 1 day).	R3 events cause a wide area blackout of HF radio communication and loss of radio contact for about an hour on the sunlit side of Earth. LF navigation signals may be degraded for about an hour. F: about 140 days per solar cycle.
Severe G4 S4 R4	G4 events may cause widespread voltage control problems for power systems, and mistaken exclusion of key assets from a power grid by some protective systems. Satellites may experience surface charging, tracking and orientation problems that may need correction. Pipelines may experience induced currents. HF radio propagation sporadic. LF radio disrupted. Satellite-based navigation may be degraded for hours. F: about 60 days per solar cycle.	S4 events can expose persons in high-flying aircraft to a radiation risk* in areas of high latitude. Satellites may experience memory device problems, imaging systems noise, orientation problems, and degraded solar panel efficiency. A blackout of HF radio communications is likely through the polar regions. Increased navigation errors over several days are likely. F: about 3 events per solar cycle (each can exceed 1 day).	R4 events cause an HF radio communication blackout on most of the sunlit side of Earth for 1 to 2 hours, with HF radio contact lost during this time. LF navigation signals cause increased errors in positioning for 1 to 2 hours. Minor disruptions of satellite navigation are possible on the sunlit side of Earth. F: about 8 days per solar cycle.
Extreme G5 S5 R5	G5 events may cause widespread voltage control and protective system problems in power systems, with some grid systems completely blacking out or collapsing, and possible damage to transformers. Satellites may experience extensive surface charging, orientation, tracking, and linkage problems. Pipelines may receive induced currents reaching hundreds of amps. HF radio may be out for 1 to 2 days in many areas. LF may be out for hours. Satellite-based navigation may be degraded for days. Bright auroral lights visible at night. F: about 4 days per solar cycle.	S5 events can expose persons in high-flying aircraft to a radiation risk* in areas of high latitude. Satellites may be rendered useless, may receive permanent solar panel damage, or may experience memory problems, loss of control, serious imaging data noise, and navigation problems. Complete HF radio communications blackouts are possible throughout the polar regions. Navigation operations will be extremely difficult and error-laden. F: less than 1 event per solar cycle should occur, although an event may exceed 1 day in duration.	R5 events cause a complete HF radio blackout on the entire sunlit side of Earth for a number of hours. No HF radio contact with mariners and aviators in this sector. LF navigation signals experience outages for many hours on the sunlit side of Earth, causing loss in positioning. Satellite navigation errors in positioning increase for several hours on the sunlit side and may spread into the night side of the Earth. F: fewer than 1 event per cycle.

*** Pregnant women are particularly susceptible to radiation risk.**

Meteors are commonly observed, illuminating briefly in the sky as the force of friction with the Earth's atmosphere burns away the solid matter they contain. Some meteors partially survive this process and thus become meteorites by striking the Earth's surface and potentially causing great amounts of damage. However, there are cases in which huge fiery blasts occurred in the sky (bolides) without any meteorite remnants being found. Enormous damage can still occur at ground level from the effects of the heat, blast force, and strong winds that result from the atmospheric impact (see the description provided for the 1908 event at Tunguska, Russia, later in this section). In addition, the effects of the sonic boom and blast wave from a less severe event, such as the one at Chelyabinsk in February of 2014, has been seen to be widely damaging to urban areas, because of the large amount of glass that is used in built structures.

Part of the usefulness of this analysis is meant to involve the presentation of information that might alleviate confusion throughout Michigan's communities and residents, in case some event actually does occur, or should some warning of an impending impact eventually be given out. In the former case, those who already have some information about meteors, and the potentially spectacular appearance of either sky or ground impacts, would have a means to make sense of an unusual bolide or impact event and would be less likely to mistake the event for a nuclear explosion. A greater general awareness of the variety and nature of Michigan's hazards should eventually translate into a lessened demand for emergency services and information. For example, it might take only 30 seconds to explain to a knowledgeable citizen that a meteor impact caused a huge explosion in the sky (and an impact on the ground), whereas a less-knowledgeable citizen might seek 20 minutes of reassurance that the explosion was not nuclear, that the incident was not connected with a crashing airplane or a confidential military experiment, and so on. The provision of advance information that realistically describes and assesses the nature of unusually severe events can help to provide a framework in which the correct interpretation and response actions can be undertaken more quickly and efficiently.

In the latter case, involving an alert about an impending impact or potential impact, many persons would need information that allows them to understand the nature of the threat, and the techniques that may be used to prevent or mitigate its impacts. For example, there is an enormous difference between an alert that provides only a few weeks of notification, and one that has identified a need for action over the course of several decades.

It should be realized that although the atmosphere and air around us seems to be "light" and only a small obstacle to movement (mostly at high speeds or during strong wind gusts), the air nevertheless has enough substance to sustain heavy aircraft in flight, to hold aloft huge thunderstorm clouds full of rain, and so on. A meteor crashing into the atmosphere thus releases tremendous amounts of energy, as the result of friction from plunging through large quantities of air at enormous speeds. This energy can result in large (and loud) blast waves, even if the meteor's trajectory is oblique enough to cause it to "bounce off" the atmosphere, rather than plunging through it and hitting the ground. For example, if a towel is wrapped around a bowling ball, a baseball can easily be bounced off the top of the bowling ball without leaving a dent or scratch in the bowling ball's surface, but it would still make a clearly audible noise and could crush any small insect that happened to be crawling underneath the towel. The towel can be seen as an analogy for our ecosphere on the surface of the planet, and the visible results of such an atmospheric impact could include great bursts of flame, damaging shock waves, severe winds, deafening noise, and disrupted weather patterns.

While this section is not intended to focus upon planetary life-ending scenarios (which are remotely possible but extremely unlikely to occur within our lifetimes), it does consider the possibility of a major (averaging once per century) impact that may cause either an area of widespread destruction within the United States, or an impact somewhere else in the world that may cause unusual effects to be felt in distant locations. If a Tunguska sized event (see the 1908 entry in the list of Significant Events later in this section) were to affect a densely populated area, the results could be extreme enough to constitute a National Emergency. (Please refer to the new section describing "Catastrophic Incident," for more discussion about this, as well as the Nuclear Attack section, for more information about problems such as mass fires, which may arise from large blasts.)

This section also considers more common events that have fairly limited effects and damages, but may be associated with a significant degree of uncertainty about the area and population that could be struck by such impacts. Even though the number of celestial impact events has probably not increased in recent times, certain types of vulnerability have increased (see for example the description of the 1859 Carrington Solar Flare event, in the section describing Significant Events). Our public awareness of these possibilities has also increased, resulting in a need for additional information to inform citizens about the actual risks, effects that different types of celestial impact may have, and

present-day means to prevent or mitigate some of the worst possible impact scenarios. Most significantly, the size of the human population, and the amount of land area it occupies, has changed greatly during the past century. The global population is nearly four times what it was a century ago, and (especially in the richer nations) this population growth has been accompanied by a much larger portion of the land area that has been built-up for urban uses. Just since World War II, the population of the United States has more than doubled, and even in areas with a relatively stable population, residential neighborhoods take up a lot more space today than they previously had in the period of time before the suburban "explosion." A random impact point today is more likely to affect lands that are developed to at least a moderate residential capacity, which could result in thousands of casualties.

Although most comets and asteroids have very consistent trajectories that change only very slowly, in terms of human history, Earth-threatening space bodies may still remain undiscovered by humans. There is also the possibility that their traditional orbits may be unexpectedly disrupted by collisions with other bodies, or by gravitational effects such as that exerted by Jupiter on Comet Shoemaker-Levy 9, which caused that comet's eventual impact into the planet. "Jupiter-family comets" are those in which a normal (safe) orbit of a comet or asteroid may be "suddenly" altered in a manner that causes it to become a threat to Earth. In either case (a newly discovered object or one whose course is changed), the possibility exists that a serious impact threat may suddenly be discovered. However, extensive observations and calculations have been taking place to identify and track all potential threats of this kind.

It is likely that the next major celestial impact will occur somewhere in the world other than Michigan, and that Michigan's role as part of the United States would at most involve the provision of support to the impacted area and its surroundings. If a major impact happens to occur in North America, then state-level mutual aid may result, and possibly even the intake of evacuees, as had taken place during the Katrina and Rita hurricane disasters of 2005. Several recent bolide events have been documented in the Great Lakes area, but have caused no known damage to the state's area during its European historical era over the past four centuries. It is possible that certain unexplained seismic events reported in the Upper Peninsula more than two centuries ago may have been caused by celestial impacts. For the most part, however, the meteorite hazard is important to know about mainly for preparedness and informational usefulness, rather than due to an actual pattern of damaging effects upon Michigan.

The space weather hazard, by contrast, is likely to cause one or more serious infrastructure failures in the near future, due to the extent of our reliance on complicated electronic and satellite systems that are vulnerable to disruption. In addition to power failures and phone communication breakdowns, it is also quite possible for the disruption of radio and navigational systems to cause risks for air and marine traffic. Even if cautious transportation providers are diligent about maintaining safety during such events, considerable economic impacts and delays can result from the electronic breakdowns caused by solar geomagnetic storm events.

Impact on the Public

A celestial impact from an object that is either sufficiently massive or fast-moving can have an effect that is comparable to nuclear blasts, in terms of the amount of energy released in the form of pressure (shock) waves and thermal effects (heat/fire). Additionally, major earthquake activity would be felt in areas that normally wouldn't have had to worry about such effects. An impact into major water bodies can cause intense tsunamis to occur, and severe winds could also result in extensive physical damages many miles (or hundreds of miles) away from the main impact site. Depending upon the mass and velocity of the meteorite, the impact on the public may range from the barely noticeable to the complete destruction of the entire area, with the most powerful impacts having effects similar to those described for nuclear attack (minus the radioactive fallout and electromagnetic pulse), earthquake, severe winds, wildfires, and storm seiches (shoreline flooding), all described in their own sections in this document. Space weather impacts will result in transportation delays and communication interference, and some cases may result in fatal transportation accidents, large economic losses, and widespread power supply interruptions.

Impact on Public Confidence in State Governance

If a major impact occurs in Michigan or the Great Lakes, many persons may feel disgruntled if no advance warning was able to be provided. There is probably not a widespread familiarity with this type of hazard, and popular conceptions may be rooted in televised or cinematic portrayals in which it was considered that part of the government perhaps "should have known" about a potential impact and been able to prevent it. One of the reasons that this hazard is now being included in state plans is to help provide information that will improve people's understanding of it. Moreover, since a significant celestial impact event could easily be mistaken for a nuclear blast by many persons, an

educational process could be useful in overcoming the possible harm caused by such assumptions. For example, if a large bolide is seen, or actually damages an area, it will be helpful for people to have been familiar with what the event actually might be, rather than assuming that it was a deliberate hostile action that may involve secondary radiation and security impacts, or assuming that a mass evacuation or escalated level of security alert may be needed. Rather, if it is understood that there is a natural phenomenon that in some cases may resemble that of an atomic blast or explosive attack, then people's behavior and attention can be more properly guided toward activities and attitudes that are appropriate for a natural disaster rather than those for a homeland security alert. The potential impacts of space weather will require greater public awareness in order to build an understanding about existing weaknesses and the expense involved in correcting those weaknesses, where possible.

Impact on Responders

A small impact incident would not be likely to cause much risk for responders, unless the impact was upon a structure that became weakened to the point of potential further collapse. Larger impact incidents would be extremely unusual, but may be expected to require extensive search and rescue operations, as well as various firefighting operations and probable infrastructure failure impacts to be dealt with simultaneously. The presence of hazardous materials could also be expected at an impact site that had been urban in nature, or had involved key agricultural or infrastructure facilities. A catastrophic impact event could require extensive use of mutual aid and state/federal disaster and emergency assistance, with the possibility that all normal response resources would be disabled within the area of impact, and would need to be replaced by resources from adjacent local areas, or even from beyond the state. Underground sheltering would be a useful way to increase the odds of survival from the wind/shock/frame effects of a huge bolide event, which would likely pass quickly and then enable responders to deal with rescue operations, fires, infrastructure failures, and the organization of mutual aid. The impacts of space weather include interruptions in the function of radios, satellites, electronics, and even power supply systems that may be needed for emergency response. Response activities that involve electronic navigation technologies and Global Positioning Systems may need to fall back upon the use of less technologically advanced means to accomplish their mission.

Impact on the Environment

An extremely large impact, even if not in Michigan, could cause a National Emergency situation to arise, which Michigan may have to help to respond to and recover from (please refer to the chapter on catastrophic incidents). A direct meteorite impact on land could destroy an entire area, and cause fires, earthquakes, and other hazards for a large area around the impact. The same types of effects can also result from the atmospheric blast and heat impacts of a large bolide event, even if the celestial body itself does not strike the ground. A large impact in one of the Great Lakes could cause substantial flooding, seiche, and erosion impacts along areas at or near the lake's coasts. It has been speculated that space weather may be connected with global climate, but this is primarily due to the possibly coincidental occurrence of a "Little Ice Age" (lower average temperatures in America and Europe) during the same time that the Maunder minimum in solar activity was observed. The specific mechanisms that would underlie such a connection have not yet been figured out and therefore such a link should probably still be considered to be purely speculative. On the favorable side, solar activity helps to shield us from some of the cosmic rays that come from throughout the universe.

Significant Events

NOTE: Although many of the events listed here occurred out of state, some of them were nevertheless large enough to have direct impacts upon Michigan, due to the sheer magnitude of the impacts. Other events are included from a very long time ago, as well as smaller more recent events, to give an indication of the magnitude of what is possible. Some events describe "close calls" and events whose limited impact at the time could have been much greater had they affected a more densely developed location (for our current circumstances involve much greater population density and physical/infrastructure developments than had been present in the past). Some events are included because they help to indicate the range of threat posed by the hazard—events outside of Michigan usually represent the largest known events or threats, while events involving Michigan tend to represent the typical level of recorded impacts in the state.

<u>Ancient-Archaic Events</u>

Approximately 1.8 billion years ago – Sudbury, Ontario

One of the largest known impacts took place around Sudbury, Ontario, leaving impact effects that measure 155 miles in diameter. The impact site's geological structure had been discovered in 1883 but not fully explained until 1964. Debris ejected from the impact site was thrown as far as the Midwestern U.S., including

Michigan. This was an impact of global significance. The heat directly generated by this cataclysmic impact would have killed any humans within at least 500 miles from the impact site (which includes all of Michigan), if humans had been living in the area at the time.

Approximately 450 million years ago – Cass County

An impact, now designated Calvin 28, struck what is now southeastern Cass County, Michigan, and left effects that are still geologically detectable today. The Calvin impact area is about 5 miles in diameter, and is located mid-way between the Village of Vandalia and the Michigan-Indiana State Line. About the same time (in geological terms), a much larger impact occurred on what is now the northern coast of Lake Superior (the Slate Islands in Ontario) and formed an impact structure about 19 miles in diameter. The following map shows the Cass County impact area (Source: University of New Brunswick's Earth Impact Database website).

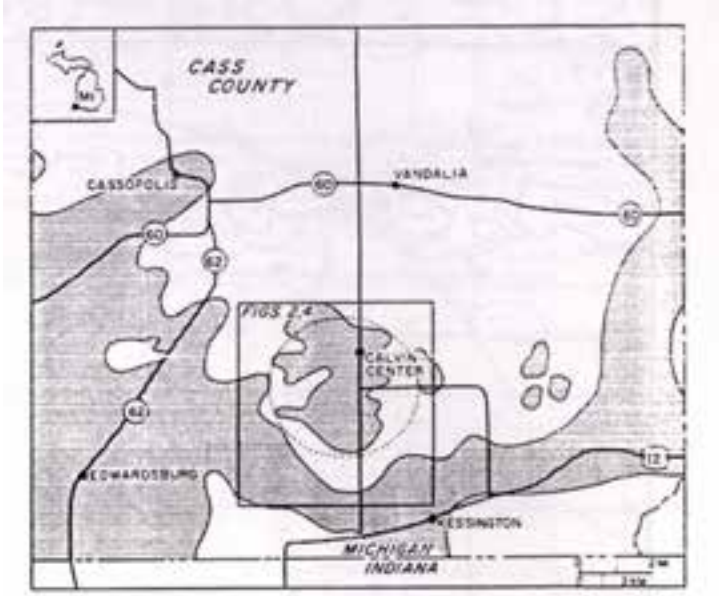


Figure 1. Map of the southeastern part of Cass County, Michigan, showing location of the Calvin 28 cryptoexplosive disturbance (dotted circle). Shaded area, Ellsworth Shale; unshaded area, Coldwater Shale.

Several hundred million years ago – Indiana and Ohio

A Kentland, Indiana impact leaves a crater estimated to have originally measured 8 miles in diameter. A smaller (5 mile diameter) Ohio impact later had Native American burial mounds built on its site, and is now known as the Serpent Mounds.

Approximately 65 million years ago – Global

A large impact on the Yucatan peninsula of Mexico (the impact area is now known as Chicxulub) took place at the end of the Cretaceous (geological) period, and thus has been considered to be a direct or contributing cause of the extinction of many prominent species of life on Earth at the time, including the large reptilian dinosaurs. There may be galactic cycles that make major, species-threatening impacts more likely during certain periods of time than others, with mass extinctions seeming to correlate with intervals of between 26 and 32 million years in length (over the past 250 million years), perhaps caused by some celestial event that sweeps Oort Cloud or Kuiper Belt objects from the outer parts of the Solar System toward Earth, or by the effects of a nearby star going supernova. Certain regions of the Milky Way Galaxy, which the Sun passes through on a grand cycle that repeats every 225 to 250 million years as it orbits the galaxy's center, may expose the Earth to more celestial bodies than are normally seen in the Solar System during the more stable, intervening time periods. Since the most recent mass extinction period was about 11 million years ago, there is no expected threat of this type during our lifetimes. The Chicxulub impact structure measures about 100 miles in diameter. Recently, evidence has been claimed for an even larger impact site, at around the same time, off the west coast of India. A surge in volcanic activity took place in the same geological time frame as the impact events and thus may have been a result of them.

About 37 million years ago – Ontario

Another impact occurred near the huge Sudbury, Ontario site (mentioned previously) and today is known as Lake Wanapitei, which is just under 5 miles in diameter.

About 50,000 years ago – Arizona

An impact forms the Barringer Meteor Crater in Arizona, which currently measures 570 feet deep and 1.2 miles in diameter. Evidence suggests that it was formed by an iron-nickel asteroid measuring about 100 feet in diameter, moving with an original velocity of 45,000 miles per hour. The impact probably caused hurricane-force winds more than a dozen miles from the impact site, the formation of a huge cloud of dust and debris, and the displacement of more than 300 million tons of rock.

Circa 900 C.E. or later – Alberta

An impact ("Whitecourt") at Alberta, Canada, leaves a crater that is more than 100 feet wide (now called the Brenham Crater).

Circa 1000 C.E. or later – Kansas

A Haviland, Kansas impact leaves a crater about 50 feet wide. (Also, during the same approximate time period, an impact occurred at Sobolev, Russia, leaving an impression about 3 times as wide.)

Modern Events

July 1, 1770 – International

Lexell's comet (D/1770 L1) was computed by astronomers as having passed only about 1.4 million miles from Earth (less than 6 times the average distance of the Moon, or about 1.5% of the distance to the Sun). This was the nearest such Earth encounter to be measured astronomically rather than in terms of its actual impact effects as a meteorite (until the very recent tracking of smaller and slower objects). Now considered to be a "lost comet," its orbital period had been calculated at the time (by Lexell) to be 5.6 years, eventually leading to the idea that space objects may be propelled toward Earth by a gravitational encounter with Jupiter—a circumstance that is one of the potential sources of comet/asteroid impact threats that would provide little or no advance warning. The comet was initially observed on June 15, 1770, and was last observed moving away from the Sun on October 3 of the same year.

September 1, 1859 – International

A large solar flare was briefly observed by astronomer Richard Carrington. Just before dawn of the next day, however, brilliant auroras were visible in skies around the world, telegraph systems severely malfunctioned, and various damages (and minor injuries) resulted from sparks and equipment failures. This was the first solar flare observation and it was also clearly seen that the phenomenon was connected with malfunctions in electronic communications systems on Earth. No solar flare of this magnitude has been seen in the 150 years since this occurred. Based upon evidence from arctic ice, it was estimated that the 1859 solar geomagnetic storm was the most intense in the past 500 years, nearly twice as much as the second-largest event. (Even though certain intensities have since been matched, no storm since has been able to simultaneously match this one, on all types of intensity measures.) Were such an event to happen again today, it has been estimated that tens of billions of dollars in damage would be done to the more than 900 satellites that orbit the Earth. These satellites are essential for the safe and smooth operation of airlines, spacecraft, and various communications systems.

1863 – Arabian Peninsula

An event more than 300 miles southeast of Riyadh, Saudi Arabian, left an impact site of probably at least five craters (Wabar Craters) in the desert, one of which was more than 100 meters in diameter. The impact compressed desert sand into rock. The date of the event is approximate, because the impact site itself was not reported until 1932, but was then considered in retrospect to match up with fireball reports that had come from the city of Riyadh in 1863. It has been calculated that the impact occurred with the force of a Hiroshima-sized atomic bomb, but fortunately in this case, it affected only an uninhabited desert area.

June 30, 1908 – Russia

A large impact event occurred in Tunguska, Russia (in Siberia), in which a large object blasted into the atmosphere in a manner that created a forceful, spectacular, and destructive impact. Although the object was evidently destroyed in the air (leaving no impact crater like so many rocky meteoroids have), the force of this destruction has been estimated as equivalent to between 5 and 30 megatons of TNT, flattening an estimated 80 million trees over an area of approximately 830 square miles (a surface area equivalent to that of a disc 32½ miles in diameter). Brilliant meteor impacts like this have been termed "**bolides**," since they can resemble fireballs and are observed as explosive, incendiary events. Unusual levels of acid rain followed the event. Recent research from Cornell University concluded that the event was "very likely" a comet impact (with most of its mass in the form of ice that would dissipate in the atmosphere), since high-altitude noctilucent clouds (which normally occur only with certain types of icy, high-altitude conditions) were sighted across Europe for several days (as much as 3,000 miles away), and caused the night skies to glow. Estimates about the frequency of this scale of impact vary from once every thousand years to once per century.

May 1921 – International

An extremely strong geomagnetic storm occurred—the strongest such storm since 1859. According to one study, if a storm of this magnitude were to occur today, it could result in large-scale electrical blackouts that would affect more than 130 million persons across the northwestern U.S. (including Michigan) and the Pacific Northwest. These estimates were based upon estimates of regions susceptible to power grid collapse, and the 1921 storm was considered to be about 10 times as strong as the one that did cause power failures in 1989. Extra-high-voltage transformers were considered to be a particular vulnerability in these projected blackout areas, with places like New Hampshire, New Jersey, and Pennsylvania at particularly high risk in the interconnected grid.

February 12, 1947 – Russia

A bolide event that included many meteorites took place in far-eastern Russian Siberia (Sikhote-Alin), fortunately occurring in a relatively isolated and undeveloped area, between China and Japan. The event was reported as a fireball, brighter than the Sun, at 10:38 am (local time). As the bolide descended at an angle of 41 degrees, it left a trail of smoke and dust 20 miles long that remained visible for several hours. The meteorite was broken into fragments as it fell at roughly 31,000 miles per hour. Upon reaching an altitude of about 3.5 miles, the bolide culminated in a giant explosion, scattering its remaining debris over an impact area of about one-half square mile. The largest impact crater in this area measured 85 feet wide and 20 feet deep. The total mass of all the meteorites from this event has been estimated as just under 1,000 tons, with the largest fragment later weighed at 1,745 kilograms and displayed in Moscow.

September 17, 1966 – Lake Huron

A bolide event occurred over Lake Huron, Michigan, involving an air blast estimated as the equivalent of 1/3 ton of TNT, approximately 8 miles above the surface of the water. Although no material from a meteorite was found to help determine more information about the size and characteristics of this meteor, this is not surprising since the location of the event probably placed any meteorite remnants at the bottom of Lake Huron. The bolide illuminated the whole of south-western Ontario and adjacent regions at about 8:48 pm, as it was seen traveling northwest across Lake Erie and the tip of Ontario, toward Lake Huron. At least a dozen loud "detonations" were reported from the Ontario area near the lake a few minutes after the fireball's passage. Astronomers later calculated that the meteor was about 8 miles up as it crossed over Lake Huron, and probably reached the lake's surface fewer than 18 miles west of the city of Kincardine, Ontario. The meteor was traveling about 10.6 miles per second (38,000 miles per hour) and was brightly luminous for at least 10 seconds.

February 8, 1969 – Pueblito de Allende, Mexico

A large shower of stony meteorites fell near a village in the Mexican border state of Chihuahua. More than two tons of meteorites fell in that incident.

August 4, 1972 – Illinois

A huge solar flare ended up causing the failure of long-distance telephone communications across Illinois. AT&T redesigned its power system for transatlantic cables as a result of this event.

August 10, 1972 – Western U.S. and Canada

Since the angle of approach varies widely, some meteors simply graze or bounce off of the atmosphere. In 1972, such a fireball was seen from Utah to Alberta.

January 1978 – International

A Soviet satellite, Cosmos 954, which had been launched in September of 1977, was being monitored by U.S. agencies and by November was found to have a decaying orbit. By January, it had become apparent that the satellite had lost its attitude stabilization system. Such satellites were known to be powered by small nuclear reactors, using fuel that was 90 percent enriched Uranium-235. Thus, whenever and wherever this satellite fell to Earth, it had the potential to contaminate things and persons who came into contact with it. The U.S. National Security Council arrived at an estimate that there was only about a 1 in 10,000 chance that a human would be injured in the crash, but because of the political aspects of an enemy nation's nuclear satellite crashing onto friendly territory, it became important to treat the incident with more weight than what that small risk might normally be credited with. Operation Morning Light was thus created, in December of 1977, with the Department of Energy given lead responsibility for the possibility of a domestic crash site. Even though a crash site for the projected landing orbit was only supposed to have an 8% chance of being on land, plans were made for such a contingency, which would involve the finding of radioactive debris, decontamination of affected land areas, and the treatment of any persons within an unsafe distance of such debris. After about 10 days of careful inquiries with the Soviet government, various types of confirmation were received about the satellite's nature and condition. On January 24, the satellite entered the atmosphere over Queen Charlotte Island, British Columbia, and at 6:53 am, finally crashed near the Great Slave Lake, just north of the Province of Alberta, in Canada. Aircraft and Nuclear Energy Search Teams were then dispatched to Canada, to assist with clean-up operations.

July 11, 1979 – International

The Skylab Space Station, which had been put into orbit in 1973 but abandoned in 1974, had its orbit finally deteriorate to the point where it plunged to Earth. Delays in the launch of the Space Shuttle program prevented the station from being salvaged by restoring it to a sustainable orbit. Instead, considerable uncertainty was expressed in the media about where the station might return to Earth, and with what potential for destructive impacts. Skylab re-entered the atmosphere on July 11 and the calculated area at-risk turned out to be in the Southern Hemisphere around the Indian Ocean. Debris impact areas on land were identified in Western Australia, the largest being a heavy metallic fragment (perhaps 5 feet in length).

March 13, 1989 – Canada and Eastern United States

Geomagnetic storms caused by a huge solar flare caused widespread disruptions in the transmission of electrical power, causing a widespread blackout across most of Quebec and affecting 6 million persons for a period of up to 9 hours. Specifically, when five transmission lines went down, the system was unable to withstand the loss of their 21,350 megawatt load, and collapsed within the subsequent 90 seconds. The blackout closed schools and businesses, shut down the Montreal Metro Airport, and delayed flights from other airports. Street traffic backups took place, since traffic signals and traffic control systems no longer functioned smoothly. Workers in downtown Montreal were stranded in dark offices, stairwells, and elevators. Elsewhere, power surges caused by the geomagnetic storm (geomagnetically induced currents, or GICs) caused power transformers in New Jersey to be overloaded and damaged. The functioning of long-distance telephone cables were also affected by auroral currents, major power substations experienced voltage swings, generators went offline, and the U.S. Air Force temporarily lost its ability to track satellites. Costs from the loss of power exceeded $100 million, including stalled production processes, idled workers, and spoiled products. This was considered to be the strongest geomagnetic storm of the space age.

October 9, 1992 – New York

The "Peekskill Meteorite" damaged a parked car in Peekskill, New York, after creating a bright fireball in the sky that was seen across several states. The original meteor (estimated to be 1 to 2 meters wide) had fragmented at a height of about 41.5 km, then again about 20 seconds later, until it was under a foot in diameter.

January 1994 – Canada

Inclement space weather caused electric charges to build up and then discharge within the electronic components of two expensive communications satellites. One satellite was disabled for about 7 hours, due to damage to its control electronics. A second satellite went out of service entirely, when its backup systems also became damaged, requiring 6 months of service before its functions were restored. The satellite disruptions prevented news information from being electronically delivered to 100 newspapers and 450 radio stations. Television and data services to more than 1,600 remote communities broke down with the second satellite failure. Telephone service in 40 communities was also interrupted. Total costs of the event were estimated at between 50 and 70 million U.S. dollars.

July 15 to 24, 1994 – International

Comet Shoemaker-Levy 9 crashed into the planet Jupiter, after being broken into 21 fragments by gravitational forces, and caused enormous impacts, which quickly became visible to telescopes on Earth. (The impact took place on the far side of Jupiter, but the planet quickly rotated and allowed the impact points to be visible). The energy released by this impact was estimated as greater than many thousands of 50-megaton nuclear bombs, as the comet's debris was vaporized and released enormous amounts of heat, temporarily exceeding the amount given off by the entire (exothermic) planet as a whole and also exceeding the temperature of the surface of the Sun. The impacts caused atmospheric spots to appear that were comparable in size to the diameter of the Earth. The comet had first been detected by astronomers only 17 months prior to its impact. It was calculated that on the comet's previous approach toward Jupiter on July 7, 1992 (which tore it into fragments), its distance from the planet was only 16,000 miles (less than the circumference of the Earth). It was estimated that the largest fragment of the comet may have exceeded 2 miles in diameter. As a result of this impact, the U.S. Congress asked NASA to propose how to identify and track all large space objects with the potential to impact the Earth.

March 19, 1996 – International

A celestial "close call" involved asteroid 1996 JA1 (large enough to cause catastrophic damage), which came within 280,000 miles—nearly as close as the Moon.

January 11, 1997 – International

A satellite that had cost $200 million was incapacitated by the impact of a Coronal Mass Ejection. After efforts to restore the satellite's function failed, it was officially decommissioned.

September 1, 1997 – Salem Township (Washtenaw County)

After numerous persons reported a bright daylight meteor and sonic booms, the object broke up into at least three parts. One meteorite (called the "Worden Meteorite") then struck a residential garage roof (in Salem Township, midway between the villages of Salem and Brookville), as the family was nearby working in their back yard. They had heard a whistling sound passing overhead, and then investigated a boom and crash, finding the garage full of plaster dust, pieces of drywall, and insulation. There was a dent in the roof of a car that was parked in the garage, and the meteorite itself was found on the floor nearby, along with a couple of associated fragments. The large meteorite weighed about 1.5kg, and its dimensions were about 6 inches long, 4 inches wide, and an inch thick.

April-May, 1998 – International

The failure of the attitude control system of an expensive Galaxy IV satellite (the cost of such satellites is usually on the order of $200 to $250 million) disrupted the function of about 45 million pagers. Various other satellite problems were noted, and researchers eventually concluded that these problems were "caused, or at least exacerbated by" the impacts of geomagnetic conditions originating from "highly disturbed" solar conditions. Although the satellite problems occurred in May, weeks of problematic space weather that had started back in April was considered to have eventually led up to May's events.

June 14, 2002 – International

Another "near miss," in celestial terms, as asteroid 2002 MN passed within 75,000 miles of the Earth, but wasn't spotted until three days after it had already passed. An impact from the asteroid would have been of Tunguska-like force.

Feb 1, 2003 – National

The Space Shuttle Columbia broke apart violently when returning from a mission, causing a widespread alert about the potential for falling debris across the southwestern United States. More than 2,000 debris impact sites were eventually reported, but fortunately these were predominantly in sparsely populated areas. NASA issued warnings that the shuttle debris could contain hazardous materials and that it should remain untouched (and instead be reported to authorities upon discovery).

March 26, 2003 – "Park Forest event" in Suburban Chicago, Illinois

Hundreds of meteorites fell across residential areas in the suburbs of Chicago. Although meteors were visible from Michigan and the meteorites landed fairly close to Michigan territory, it must be noted that this event is highly unusual, having been described as "the most densely populated region to be hit by a meteorite shower in modern times." Coincidentally, the area of impact was in the midst of numerous highly-trained experts associated with the University of Chicago and other scientific institutions. The original meteoroid was calculated to have been between 1 and 7 thousand kilograms (possibly more) before it broke apart in the atmosphere. About 30 kilograms of meteorite fragments were recovered, the largest of them weighing 5.26kg. Numerous holes were punched through windows, roofs, and ceilings in homes, and also a fire station. One roof hole was caused by a meteorite that weighed only 545 grams. There were about 18 documented fragments of about that size or larger across a couple of square miles of neighborhoods.

October and November, 2003 – International

Geomagnetic storms took place in late October and November, and although power grids had learned from the March 1989 event and were better able to withstand the storms' effects, there were some heavy impacts upon the aviation sector from this event. The FAA had implemented a WAAS (Wide Area Augmentation System) to better guide navigation and aviation system control, and a part of what WAAS supports is the ability of air traffic to maintain safe distances from each other. The vertical navigation component of WAAS was disabled for approximately 30 hours across most of the United States during the late October storms.

January 2005 – International

Space weather at this time included solar radiation storms. In addition to the loss of HF radio communications, such storms can cause elevated radiation exposure to persons in aircraft flying at high latitudes (e.g. across polar regions). The use of polar routes has increased dramatically since the 1990s, since such routes can reduce travel time and fuel costs (by avoiding strong wintertime headwinds). Aircraft must divert to lower-latitude routes during such storm events, resulting in delays, increased flight times, missed connections, higher costs, and greater fuel consumption.

December 2005 – International

A geomagnetic storm caused the disruption of satellite-to-ground communications and GPS (Global Positioning System) navigational signals. Although this disruption only lasted about 10 minutes, it threatened the safety of commercial air flights and marine traffic during that time.

December 6, 2006 – International

A burst of solar radio wave energy caused a disruption in the function of GPS units across the entire sunlit side of the Earth (the Western hemisphere in this case). Some users of navigation systems found their capacities disrupted for many minutes, which was of particular significance for military aircraft.

September 20, 2007 – Southern Peru

After a loud explosion was heard, residents of an isolated village found a large crater measuring 41 feet in diameter near Lake Titicaca and filled with water. A 1.5 magnitude earthquake was detected in the area. The unusual aspect of this incident is that many villagers subsequently reported symptoms such as headaches and nausea. It has been proposed that the impact of a meteorite, along with the heat that was generated, caused the release of toxic fumes from the ground.

February 4, 2011 - International

An asteroid designated as 2011 CQ1 was the closest "near miss" on record so far, as this object came only about 3,400 miles away from Earth. Earth's gravitational pull at that distance was strong enough to change the asteroid's trajectory by 60 degrees, indicating just how close the object was, in astronomical terms.

June 27, 2011 - International

An asteroid designated as 2011 MD passed only 7,600 miles above the Earth's surface. It was discovered by LINEAR and its size was less than 20 meters in diameter. The object was close enough to markedly change its trajectory as it passed.

February 15, 2013 – Chelyabinsk, Russia

A meteor became visible in the sky, and was soon followed by a shock wave that shattered windows throughout a wide portion of the major Russian city of Chelyabinsk. About 1,600 persons were reported as injured by shattering glass throughout the city. Damage to a couple of industrial facilities also resulted, as the blast wave caused large doors to buckle and weakened structural components to collapse. The meteorite's impact location was later located in a rural area, much reduced in size from the body that had originally blazed through the atmosphere. This was the first incident in which many injuries occurred as a result of this type of hazard. The physical size of this meteorite was much smaller than the Sikhote-Alin event of 1947 or the Tunguska event of 1908. It is fortunate that only the meteoritic blast wave was felt by the city, but this event is strongly indicative of the extent of damage that this hazard can cause. The destruction could have been far worse if the trajectory of the meteorite had been different. Meteorite fragments weighing about ¾ ton were later retrieved from the impact site at Chebarkul Lake, about 40 miles away. The meteorite was determined to have originally been one of the Apollo Near-Earth Asteroids, approximately 60 feet in its original size and with a mass of about 11,000 tons before it started to burn up in the atmosphere. The total impact energy was calculated by NASA to be the equivalent of about 440 kilotons of TNT. Purely by coincidence, many persons were already thinking about asteroids, because they were anticipating the near-Earth approach of an already-known body, asteroid 2012 DA14, which passed harmlessly by the Earth about 16 hours later, with a completely different (and thus unrelated) approach directory than the meteorite had shown. The Chelyabinsk meteorite had been traveling west-northwest above the earth's northern hemisphere, approaching from the general direction of the Sun, but the path of asteroid 2012 DA14 was going in a nearly perpendicular direction, and at its nearest it was about 17,000 miles away from the Earth's surface. The temporal proximity of the two bodies was mere coincidence, although 17,000 miles is quite close, in celestial terms, for a 150-foot diameter asteroid to pass by, allowing it to be clearly photographed from the Earth during its passage.

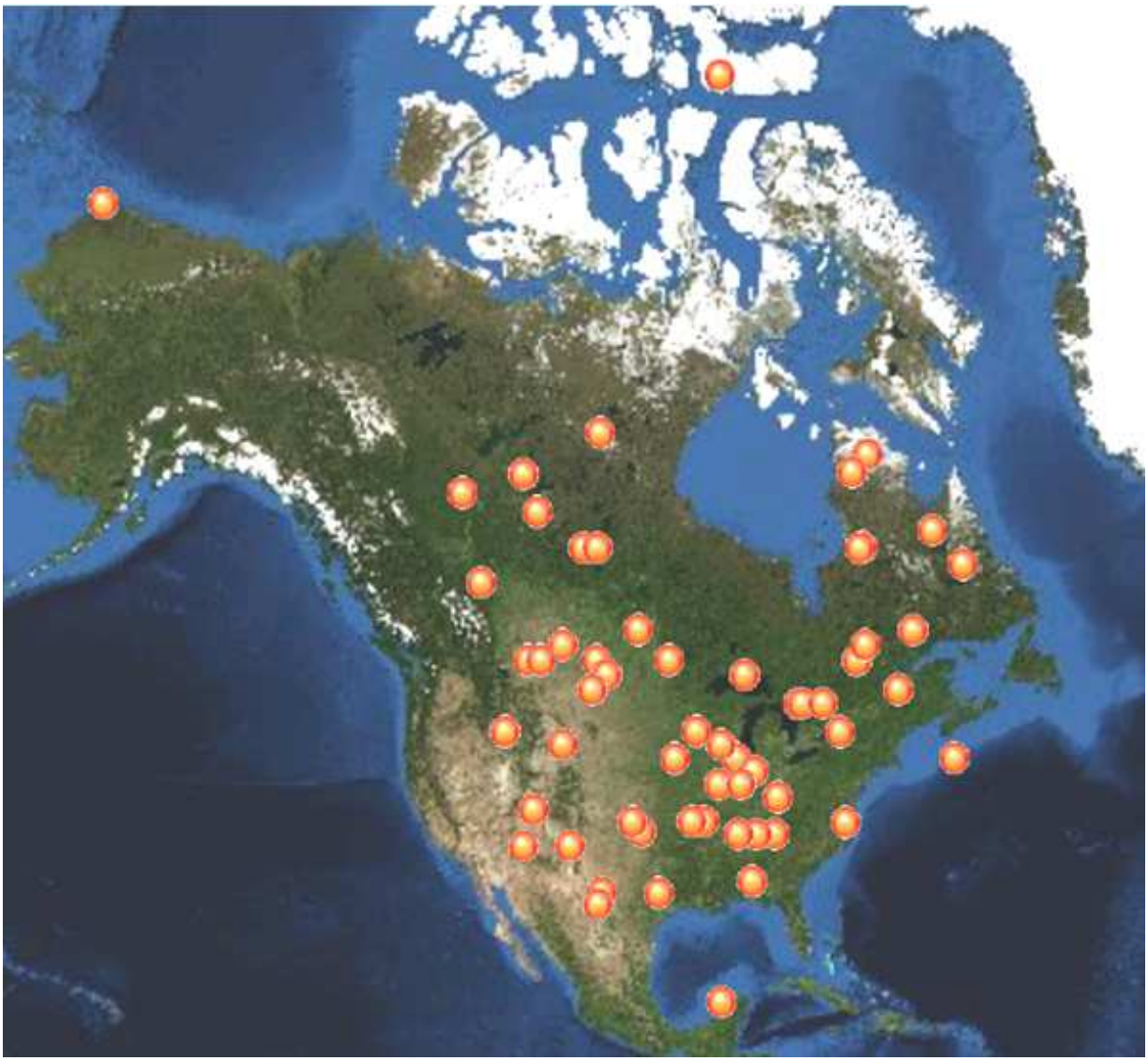


Image showing identified impact crater sites across the United States and Canada

(Map based on information from the Impact Database website – http://www.unb.ca/passc/ImpactDatabase/NorthAmerica.html)

Programs and Initiatives

In recent decades, a number of programs and research projects have examined this hazard, sought additional information about near-Earth objects (NEOs), and developed models of the potential risks and effects of an impact. Although most historic meteors went unnoticed (or unrecorded as such) in earlier times, today's satellite systems allow practically every meteor to be detected as it ignites in the atmosphere.

Near-Earth Object Detection Programs

Various agencies and universities have set up or coordinated in the creation of detection programs designed to locate and measure the characteristics of Near-Earth Objects such as "Apollo asteroids" that cross the orbit of the Earth. (It has been estimated that there are about 200 such asteroids with diameters of at least 1km, which would thus be capable of catastrophic damage if an impact were to occur. It has also been estimated, by NASA, that fewer than 10% of the estimated NEOs larger than a half-mile in diameter have yet been detected.) Most of these detection programs involve systematic telescope surveillance, measurements, complex modeling and orbital projection. Programs include the following:

- Lincoln Near-Earth Asteroid Research (LINEAR) project – at MIT, funded by NASA and the USAF.
- Lowell Observatory NEO Survey (LONEOS) program – in Flagstaff, Arizona.
- Near-Earth Asteroid Tracking (NEAT) system – operated by NASA's Jet Propulsion Laboratory in conjunction with the U.S. Air Force on Mt. Haleakala, Hawaii. The goal of NASA's 1998 Near-Earth Object Program was to locate at least 90 percent of all NEOs that are at least 1km in diameter.
- Palomar Planet-Crossing Asteroid Survey
- Panoramic Survey Telescope and Rapid Response System (Pan-STARRS) – Hawaii program supported by the U.S. Air Force.
- Raptor – a stereoscopic observation system operated by Los Alamos National Laboratory.
- The Sentry System – of the NASA Jet Propulsion Laboratory
- Spaceguard – started by NASA in 1998, a global survey devoted to asteroid analysis.
- The Spacewatch program – run by the University of Arizona in Tucson at Kitt Peak, Arizona.
- Various space missions have occurred to gather more information about asteroids and comets, and more are planned for the future. Some past missions have included Vega 1, Vega 2, Giotto, Suisei, and Sakigake (1986 flybys of Halley's Comet); Galileo (1995 observations of the Shoemaker-Levy comet impact); Near-Earth Asteroid Rendezvous (NEAR—asteroid investigations from 1997 to 2001); Deep Space 1 (comet rendezvous in 2001), Stardust (comet material collected and returned for analysis in 2006); Hayabusa (aka MUSES-C – asteroid landing and probing form 2005 to 2010); Rosetta (asteroid flybys from 2008 to 2010, and comet interception mission scheduled for 2014-2015); and Deep Impact/EPOXI (comet rendezvous in 2005 and flyby in 2010). Additional missions can be expected to provide even more information.

More information about these programs can be found at their associated web sites on the internet.

Solar Monitoring and Measurement Programs

Various spacecraft are gathering data on solar flares, coronal mass ejections (CMEs), and charged-particle emissions (solar storms and space weather). These include:

- The Solar and Heliospheric Observatory (SOHO) (http://sohowww.nascom.nasa.gov/) is a collaborative international project between the U.S. National Aeronautics and Space Administration (NASA) and the European Space Agency (ESA). It was launched in 1995. Among its solar studies, it tracks the intensity of solar winds and flares, and has also been responsible for the discovery of 2000 comets.
- Hinode – A Japanese satellite that engages in solar missions coordinated with other space agencies around the world, Hinode employs optical, ultraviolet, and X-ray equipment that measures the Sun's magnetic field, the Sun's corona (turbulent outer atmosphere), and the solar particles that are radiated.
- Solar Terrestrial Probes (STP) – Currently, the Solar Terrestrial Relations Observatory (STEREO) is the third of NASA's Solar Terrestrial Probes program and has been engaging in 3-D observations, imaging, and measurements of solar activity since 2006. Using a pair of spacecraft, the combined views cover most of the solar surface at all times, including the far side of the Sun, and make use of extreme ultraviolet waves to better detect and analyze coronal activity. A phone application is available from NASA that allows solar monitoring and the receipt of alerts to be transmitted to users' phones. The STEREO web site is located at

http://www.nasa.gov/mission_pages/stereo/main/index.html. On February 3, 2011, the two STEREO craft reached positions directly opposite each other, 180 degrees apart on each side of the Sun, allowing the entire surface to be monitored simultaneously. A Magnetosphere Multiscale (MMS) mission is planned for 2014, and will study three important plasma processes in the Earth's magnetosphere, to better understand space weather processes.

- Advanced Composition Explorer (ACE) – Launched in 1997, NASA's ACE provides solar wind monitoring and measurement in nearly real-time. From its space location at a point of gravitational equilibrium between the Earth and the Sun, ACE provides one hour of advance notice about impending geomagnetic activity that can disrupt communications and/or overload power grids. ACE instruments provide information about energetic ions and electrons, magnetic field vectors, high energy particle flux, and solar wind ions. The ACE web site is found at http://www.swpc.noaa.gov/ace/.
- Solar Dynamics Observatory – This program was designed by NASA to help understand the causes of solar variability, and its impacts on Earth. Launched in 2010, the mission focuses on the Sun's magnetic field, solar coronal activity and plasma, space weather, and the irradiance underlying planetary ionospheres. The SDO web site is at http://sdo.gsfc.nasa.gov/mission/about.php.

NOAA/NWS Space Weather Prediction Center

A web site at http://www.swpc.noaa.gov/ allows continuous access to information about space weather, including the convenient classification of space weather into NOAA's convenient 5-category schemas (e.g. from G1 to G5). Alerts and warnings are also accessible through this web site, along with a number of Space Weather User Groups, covering topics such as navigation, radio, electric power, and satellite operators.

NASA Asteroid Redirect Mission

This newly developing mission has the goal of detected, capturing, and redirecting an asteroid into a safe orbit. For more details, refer to the NASA overview presentation at http://www.nasa.gov/pdf/740684main_LightfootBudgetPresent0410.pdf.

Grid Reliability and Infrastructure Defense Act (GRID)

In 2010, the U.S. House of Representatives passed an act that included the following language specifically directed toward mitigating some of the impacts of geomagnetic storms:

"Geomagnetic storms.--Not later than 1 year after the date of enactment of this section, the Commission shall, after notice and an opportunity for comment and after consultation with the Secretary and other appropriate Federal agencies, issue an order directing the Electric Reliability Organization to submit to the Commission for approval under section 215, not later than 1 year after the issuance of such order, reliability standards adequate to protect the bulk-power system from any reasonably foreseeable geomagnetic storm event. The Commission's order shall specify the nature and magnitude of the reasonably foreseeable events against which such standards must protect. Such standards shall appropriately balance the risks to the bulk-power system associated with such events, including any regional variation in such risks, and the costs of mitigating such risks."

The full text of the act can be found at http://www.fas.org/irp/congress/2010_cr/grid.html.

The celestial impact hazard has not yet been identified as one of the most significant hazards in any of Michigan's local hazard mitigation plans.

Hazard Mitigation Alternatives for Celestial Impacts

- Advance planning for catastrophic scenarios. For example, the U.S. Air Force used an asteroid strike for its December 2008 Interagency Deliberate Planning Exercise. The after-action report for that exercise was posted online at http://neo.jpl.nasa.gov/neo/Natural_Impact_After_Action_Report.pdf. An asteroid detected at a distance equivalent to that of the Earth's Moon could still give 8 hours of advance warning for the evacuation of coastal areas (to mitigate loss of life from a projected sea impact).
- Continued surveillance and analysis of Near-Earth Objects, and support for agencies that are engaged in such work. For example, since 1975, the Department of Defense has amassed extensive data about meteors entering the atmosphere, finding that hundreds per year explode in the atmosphere with explosive energy of at least 1 kiloton.
- Existing technologies would allow the diversion of a large asteroid or comet, if a sufficient lead time is available. Objects on a collision course 10 to 100 years in the future can be diverted or reduced by the use of conventional rockets and explosives. (Such action would be coordinated in the United States by the Departments of Defense

and Energy, and would likely include international partners.) Explosives would require knowledge of an object's composition to be effective. Laser targeting could be used to change an object's velocity, although weeks or months may be required to obtain a large enough effect. With a sufficient amount of warning time (on the order of years), other mitigation techniques could include attaching a solar sail to the object, an interception/landing mission, and/or use of the "Yarkovsky effect" in which asteroid temperatures could be changed to affect its orbit.

- Various space missions have occurred to gather more information about asteroids and comets, and more are planned for the future. Some past missions have included Vega 1, Vega 2, Giotto, Suisei, and Sakigake (1986 flybys of Halley's Comet); Galileo (1995 observations of the Shoemaker-Levy comet impact); Near-Earth Asteroid Rendezvous (NEAR—asteroid investigations from 1997 to 2001); Deep Space 1 (comet rendezvous in 2001), Stardust (comet material collected and returned for analysis in 2006); Hayabusa (aka MUSES-C – asteroid landing and probing from 2005 to 2010); Rosetta (asteroid flybys from 2008 to 2010, and comet intercept mission scheduled for 2014-2015); and Deep Impact/EPOXI (comet rendezvous in 2005 and flyby in 2010). Additional missions can be expected to provide even more information.
- Awareness campaigns for industries and systems involving satellite communications, GPS, or radio communications that could be disrupted by solar flare (space weather) activity. In addition to the use of GPS for navigation, aviation, and military applications, it is also important for offshore drilling operations, precision farming, transportation, and mapping and surveying.
- Operating procedures that include back-up systems allowing complex systems (e.g. air traffic control) to continue to function when key technological systems (e.g. GPS, radio communications, satellites) malfunction. For example: the maintenance of "legacy" non-GPS navigational systems as a back-up, and the use of new GPS signals and codes to remove ranging errors.
- The use of special procedures, equipment, and redundancies by utility systems (e.g. electrical power and pipeline systems) to minimize the potential for geomagnetic effects to cause inappropriate shutdowns and system damage. For example: the provision of reserve capacity may offset the effects of geomagnetic storms, and the temporary disconnection of components for their own protection.
- Additional back-up satellites, for communications and navigation, will be needed to limit the damaging effects of a major solar storm, which may put current satellite equipment out of action and require their rapid replacements. The importance and cost of satellite systems may not be well-known to the general public. As of 2009, the existing fleet of 250 commercial satellites constituted a total investment of about $75 billion, and involved an annual revenue stream estimated at over $250 billion.

II. Technological Hazards
A. Industrial Hazards

The following outline summarizes the significant industrial hazards covered in this section:

1. Fires
    - a. Structural Fires
    - b. Scrap Tire Fires
2. Hazardous Material Incidents
    - a. Hazardous Material Incidents – Fixed Site (including industrial accidents)
    - b. Nuclear Power Plant Emergencies
    - c. Hazardous Material Incidents – Transportation
    - d. Petroleum and Natural Gas Pipeline Accidents
    - e. Oil and Natural Gas Well Accidents

This section covers many related types of events that stem from breakdowns or weaknesses in industry and the built environment. The starting section, structural fires, considers various types of large fires that occur in the midst of important buildings or structures. Since a frequent cause of structural fires involves natural gas explosions, the chapters involving natural gas (pipelines and wells) appear nearby, to make easier a more thorough reading about this shared source of risk. Although small residential fires are common, and can be the cause of larger urban conflagrations, this hazard analysis focuses in particular on those larger-scale fires that have greater potential to affect an entire community—either through a fire's sheer magnitude or through the vital nature of the facilities or resources it affects. For this 2014 edition of the Michigan Hazard Mitigation Plan, new consideration and detail is provided for "urban conflagrations" in which dense urban development may allow fires to spread over many blocks, or even the entire core of the built-up area.

Scrap tire fires are a special case of industrial hazard, for although they do not typically affect a specific structure, these types of fires do involve toxic smoke and chemical residues that have more in common with hazardous material incidents than with ordinary residential and wildfire events. The following chapters, specifically dealing with hazardous material incidents, cover a wide array of extremely hazardous substances across diverse situations that typically involve industrial or warehousing operations. The section on fixed site incidents includes a consideration of fire-related industrial accidents and explosions, even if these did not involve extremely hazardous substances. Again, the emphasis is on events of a relatively large magnitude—those that resulted in community states of emergency, evacuations, impairment or loss of economically significant or critical facilities, or multiple casualties. A separate chapter deals with nuclear power plant emergencies, and then consideration is given to various forms of transportation incidents that may involve hazardous materials, including separate chapters about pipeline infrastructure and wells that have been dug for production purposes.

Overlap Between Industrial Hazards and Other Sections of the Hazard Analysis

Various types of structural, scrap tire, and industrial fires and incidents may stem from deliberate actions, rather than accidental causes. In such cases, the incidents tie in with the terrorism and civil disturbance chapters, in the Human-Related hazards section of the hazard analysis. Large scale disaster events may also cause these types of fires to occur—lightning strikes have actually caused the direct ignition of structural fires, and the destruction caused by tornados can lead to fires as well. Wildfires have a clear potential to ignite structures, and may also come to involve scrap tire storage areas. Although the chances are slim, earthquakes and celestial impact events might also result in the occurrence of structural or industrial fires. There might be certain conditions under which infrastructure failures are connected with fires. An indirect link also exists between extreme temperatures and winter weather, as various means of heating indoor areas have been known to increase fire risks. A major transportation incident has the potential to start a fire, and certain kinds of catastrophic incidents (such as nuclear attack) would certainly create fires.

A structural fire involving one or more critical facilities has the potential to cause infrastructure failures, energy emergencies, flooding, wildfires, dam failures, transportation accidents, and nuclear power plant emergencies. Hazardous materials incidents of any type (including scrap tire fires) may lead to public health emergencies if they are large enough, or if the involved substances are hazardous enough. If a fire or hazardous materials incident stems from some sort of systematic official negligence then there may be a potential for civil disturbance or sabotage/terrorism to take place.

STRUCTURAL FIRES

A fire, of any origin, that ignites one or more structures, causing loss of life and/or property.

Hazard Description and Analysis

In terms of average annual loss of life and property, structural fires—often referred to as the "universal hazard" because they occur in virtually every community—are by far the most common hazard facing most communities in Michigan and across the country. Each year in the United States, fires result in approximately 5,000 deaths and 25,000 injuries requiring medical treatment. According to some sources, structural fires cause more property damage and loss of life than all types of natural disasters combined. Direct property losses due to fire exceed $9 billion per year, and much of that figure is the result of structural fires.

In 2008 alone, there were 3,320 civilian deaths and 16,705 civilian injuries as a result of fire in the United States, along with 118 firefighters killed while on duty. There were an estimated 1.5 million fires in 2008, and direct property loss due to fires was estimated at $15.5 billion. This figure includes the 2008 California wildfires, with estimated losses of $1.4 billion. There were 515,000 structure fires in the United States in 2008 that resulted in 2,900 civilian deaths, 14,960 civilian injuries, and $12.4 billion in property damage. Every 22 seconds, a fire department responds to a fire somewhere in the nation. A fire occurs in a structure at the rate of one every 61 seconds, and in particular a residential fire occurs every 78 seconds. Nationwide, there is a civilian fire injury every 31 minutes. In 2008, structure fires represented 34% of the total fires across the United States.

Unfortunately, although the United States has made great strides in lessening deaths and injuries caused by other types of disasters, structural fires are worse problems in this country than in many other industrialized countries (even those with a more densely-developed population pattern). The United States Centers for Disease Control (CDC) figures indicate that fire-associated mortality rates in the United States are approximately 2-3 times greater than those in many other developed countries. According to the Federal Emergency Management Agency's National Fire Data Center, residential fires represent 78% of all structural fires and cause 80% of all fire fatalities. Approximately 83% of those fatalities occur in single-family homes and duplexes. Perhaps the most tragic statistic of all is that over 40% of residential fires and 60% of residential fatalities occur in homes with no smoke alarms. (Studies have repeatedly shown that a working smoke alarm dramatically increases a person's chance of surviving a fire.)

Michigan's fire experience generally mirrors the national fire situation. According to statistics compiled by the Fire Marshal Division of the Michigan Department of Licensing and Regulatory Affairs for 2003, nearly 19,000 structural fires occurred in Michigan, resulting in 161 deaths and 624 injuries. The dollar loss for all fires was estimated at over $230 million. The Fire Marshal Division estimated that a structural fire occurred in Michigan about every 28 minutes in 2003. Michigan's fire death rate of 15.4 persons per million puts it toward the middle of all states in the nation in 2006. As the following table indicates, Michigan is ranked 19th in terms of fire deaths per million population. Michigan's fire death rate is ranked third in the Midwest, behind Missouri and Indiana as of 2007.

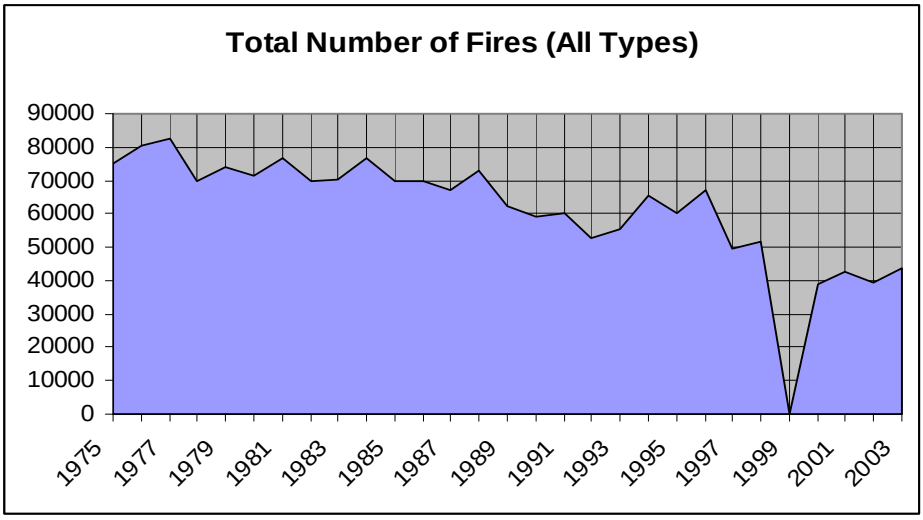
During the period from 1975-2009, the number of reported fires in Michigan (both structural and nonstructural) has trended downwards from a high of just over 80,000 to the current low of around 40,000, with yearly numbers fluctuating within this range. The number of structural fires represents approximately 35-40% of those yearly totals. Although fire risks are clearly a major concern, most of the incidents are of a limited scale and do not threaten or harm an entire community. This analysis will focus on major fires that do cause a severe impact to local communities—as disaster events.

Fire Death Rate per Million Population: 2007

State	Fire Rate	State	Fire Rate	State	Fire Rate
District/ Columbia	39.2	Indiana	15.6	Wyoming	9.6
Mississippi	28.4	**Michigan**	**15.4**	Montana	9.4
Arkansas	26.0	Vermont	14.5	Connecticut	9.2
Alaska	25.1	Nevada	14.4	Washington	8.8
Oklahoma	24.9	Illinois	14.2	Iowa	8.7
West Virginia	24.8	Delaware	13.9	Idaho	8.7
Louisiana	23.8	Virginia	13.3	Minnesota	8.7
Alabama	22.6	Wisconsin	12.7	Colorado	8.3
Tennessee	22.5	Ohio	12.5	California	8.2
Missouri	20.1	Nebraska	12.4	Arizona	7.9
North Carolina	19.5	Utah	11.6	New Jersey	7.5
Pennsylvania	19.2	South Dakota	11.3	Massachusetts	6.9
Georgia	18.8	Texas	11.2	Maine	6.8
Kentucky	18.6	New Mexico	11.2	New Hampshire	6.8
South Carolina	17.4	New York	10.7	North Dakota	6.3
Kansas	17.3	Florida	9.8	Rhode Island	5.7
Maryland	16.2	Oregon	9.6	Hawaii	3.9

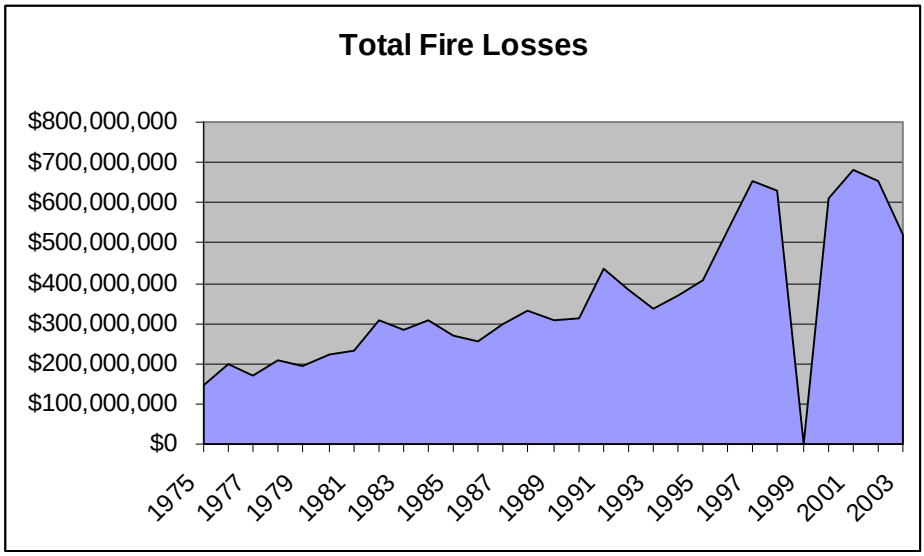
Source: U.S. Fire Administration web page, Federal Emergency Management Agency (National Fire Data Center)

Total Number of Fires (all types) in Michigan: 1975-2003



Note: There was no annual report of fires in 1999 due to the transfer to NFIRS
Source: Michigan Department of Licensing and Regulatory Affairs (LARA), Fire Marshal Division / MFIRS
(Note: Approximately 35-40% of the total number of fires are structural fires.)

Total Fire Losses in Michigan: 1975-2003



Note: There was no annual report of Fires in 1999 due to the transfer to NFIRS
Source: Michigan Department of Licensing and Regulatory Affairs (LARA), Fire Marshal Division / MFIRS
(Note: Approximately 75% of the total losses are structural fire-related.)

The State Fire Marshal, Department of Licensing and Regulatory Affairs / Bureau of Construction Codes and Fire Safety, and local fire departments are proactive in attempting to reduce the number, scope, magnitude, and impacts of structural fires in Michigan. State and local fire service efforts in the areas of training, public education, incident tracking, construction plan review, site inspection and fire analysis are all oriented toward, and contribute to, structural fire mitigation and prevention. However, like most programs, the amount of work that can be done is directly related to funding and programmatic priorities.

Nature/Composition of Michigan Fire Service

The primary challenge facing the State Fire Marshal, in particular, and the State of Michigan, in general, is the nature and composition of the Michigan fire service. The high proportion of fire fighters that are either volunteer or paid part-time (roughly 3/4 of the fire service) presents significant challenges for sustaining adequate code enforcement and inspection efforts. In addition, the relatively high level of turnover within this group places additional demands on state and local training resources. Also, with the effects of recession, especially in the State of Michigan, many fire fighters have been laid off or had their positions cut due to a lack of funding. For example, in March 2010, the city of Flint laid off 23 firefighters and 46 police officers, and closed two fire stations due to budget deficits.

The lack of full-time professional fire fighters in many areas of the state means that less time is available to conduct fire inspections and take other preventive measures necessary to lessen the structural fire threat. In many small towns and rural communities, local efforts in fire prevention are almost non-existent, due to lack of personnel and time to devote to such activities. Out of necessity, efforts in these communities are directed primarily at fire suppression. Clearly, the lack of full-time paid fire professionals in many areas across the state poses great challenges for maintaining a sustainable fire prevention and inspection program.

Lack of State Fire Safety Code

The other major challenge facing the Michigan fire service is the lack of a state-mandated fire safety code and code enforcement program for all occupancy types. Although the State enforces fire safety codes in schools, dormitories, health care facilities, and correctional facilities, plus some businesses, the remainder of the job is left to local officials. Because there is not a uniform, mandated fire safety code for everyone to adhere to, a plethora

of local ordinances have emerged. In some communities, fire safety codes do not exist at all. This contributes to Michigan's structural fire problem by allowing serious fire safety violations to go unchecked, often for years at a time. This problem manifests itself more seriously in rural areas and small towns, which typically have few, if any, paid full-time fire fighters. In Michigan's larger cities, full-time fire departments with qualified inspectors are the rule rather than the exception. As a result, fire safety inspections are performed on a more regular basis, but not necessarily as often as they should be.

Even if a mandated fire safety code were instituted statewide, it wouldn't totally solve the problem of structural fire prevention because the costs of compliance in existing buildings would often be prohibitive for business owners. Such a measure would, however, help to ensure that new construction doesn't compound the problem.

Impact on the Public

Structural fires can cause displacement and homelessness, in addition to serious injuries, death, and economic losses. Beyond the small-scale structural fires that only affect a single home or two at a time, emergency management authorities are primarily focused on disaster-level events involving multiple or major structures such as hotels, college residence halls, and major employers and community facilities (such as schools and hospitals). The impacts upon local services and economies can be severe in such cases, due to the number of residents served and the diversity of needs being met by these facilities. Structural fires occur more frequently than other Michigan hazards, and also cause more deaths, injuries, and property damage.

Impact on Public Confidence in State Governance

Structural fires may raise questions about code enforcement and other regulations that may be connected with state government. Some fires may originate from utility malfunctions (e.g. natural gas explosions) or wildfire events, and thus call into question the capacity of the state to foresee, regulate, or manage such situations. Emergency management personnel are particularly interested in structural fires that can produce disaster-level events involving major or multiple structures, major employers, or community facilities. Examples include hotels, college residence halls, schools, hospitals, factories, and "main street" commercial areas. If severe economic or service disruptions result from such fires, the viability and reliability of government operations, design standards, and procedures may be called into question. The fact that regulatory controls may be created and implemented at the local level does not necessarily absolve State government from responsibility, since municipalities are legally considered to be "creatures of the state" and could potentially have their safety policies formulated by state legislation, and implemented by state agents.

Impact on Responders

The structural fire hazard, from the perspective of emergency management, does not generally involve common residential fires that primarily affect a single home, but instead deals with large-scale events that involve critical, large, or multiple structures, utilities infrastructure, industrial facilities, nursing homes, dormitories, hospitals, hotels, and other locations that involve greater risk and complexity due to the potential numbers of vulnerable people involved, the vital nature of the site for the community, or the potential for exposure to hazardous materials. Extensive search and rescue operations may be warranted under major structural fire conditions. Special training, staffing, and equipment is often useful or necessary to effectively deal with such events.

Impact on the Environment

Air pollution issues are inherent to structural fire events, including vast amounts of carbon released from the flames, various chemicals burning within the building's materials, other forms of air pollution, and ash spread widely around the area. Large, dark, and thick smoke plumes from large burning structures can alter atmospheric conditions and lead to shifting wind patterns that affect other areas. Fires may spread to other structures and to natural vegetation, negatively affecting the environment. The burning of nearby native forests, trees, and grasslands can be some environmental consequences of structural fires. Chemicals from combustion may contaminate nearby water in lakes, reservoirs, rivers, and swamps. Agricultural structural fires can also affect farm animals and ruin agricultural products. The waters used to quell fires can spread the combustion products

(chemicals, soot, ash) into nearby areas, and into municipal sewer systems where they may affect the environment at system outlet locations.

Significant Structural Fires

Unfortunately, Michigan has not been immune to large structural fires that resulted in a significant loss of life. Michigan has not had a catastrophic structural fire disaster in recent years that resulted in a significant loss of human life or significant injury. However, in any given year it is not uncommon for several multiple-casualty residential structural fires to occur throughout the state. Despite the best efforts of fire officials in fire safety education and prevention, deadly residential fires continue to occur year after year.

For example, a January 10, 2002 arson fire at an apartment complex in Detroit killed two women and left over 100 people homeless. An August 29, 2002 house fire in Detroit killed three adults and a baby girl and also left one man injured. An October 16, 2002 fire at an unlicensed adult care facility in Flint killed five elderly residents. On January 26, 2003, a kitchen fire in a Detroit home spread through the house, killing five people trapped in by bolted burglar bars around the windows. On July 29, 2003, six persons (mostly children) perished in a house fire in Pontiac. A December 17, 2003 house fire in Grand Rapids killed all seven people inside, ranging in age from two to seventy. On January 25, 2004, burglar bars also trapped one adult and four children during a house fire at a home in Mount Morris Township, Genesee County, killing everyone inside. On July 10, 2007, two persons died in a Livingston County house fire. On Thanksgiving November 22, 2007 two people were killed in an Otsego house fire as a result of non working smoke detectors. On January 20, 2008 a massive structural fire in Grand Rapids resulted in the destruction of over 100 condominium units in two adjacent buildings. Around 200 individuals escaped the building, and although nobody was injured, four persons had to be rescued. On February 12, 2008 a fire raced through a home in rural northern Michigan before dawn, killing a man and his four children and sending the children's mother to the hospital. On September 29, 2008 a house fire in Coopersville resulted in four deaths. On April 25, 2009, a fire at a house in Texas Township, Kalamazoo County killed four young children and one adult. In May 2009 about 777 acres and 33 structures, including houses and outbuildings, burned in Marquette County, southwest of Ishpeming, and caused about 500 persons to be evacuated. On December 31, 2009, two fatalities and several injuries occurred during an apartment complex blaze in Detroit. A townhouse fire in Flint killed four children on February 14, 2010. On March 3, 2010 three children were killed during a Detroit house fire and another four survived by jumping out of a window to be caught by men who were providing assistance. On April 14, 2011 two people died in a house fire in Grand Rapids.

Fires in congregate facilities such as hotels, entertainment venues, schools, and hospitals pose an even greater risk due to the larger number of persons involved. As the following tables indicate, when catastrophic fires occur in congregate facilities, the human toll can be severe.

Catastrophic Structural Fire Disasters in the United States

HOTELS:

Structure	Date	# Fatalities	Structure	Date	# Fatalities
Newhall House (Milwaukee)	1883	71	Lane (Anchorage)	1966	14
Hotel Royal (New York City)	1892	28	Hotel Fire (Seattle)	1970	19
Windsor Hotel East (NewYork)	1899	35+	Pioneer Intl. (Tucson)	1970	28
Kerns (Lansing)	**1934**	**34**	Ponet Sqr. (Los Angeles)	1970	19
Terminal (Atlanta)	1938	35	Hotel Vendome (Boston)	1972	9
Marlborough (Minneapolis)	1940	19	Washington House (W .V.)	1974	12
Gulf (Houston)	1943	55	Pomona (Portland)	1975	12
LaSalle (Chicago)	1946	61	Path Finder (Nebraska)	1976	20
Canfield (Dubuque)	1946	19	Coates House (Kansas C.)	1978	16
Baker (Dallas)	1946	10	MGM Grand (Las Vegas)	1980	87 (700+ inj)
Winecoff (Atlanta)	1946	119	Stouffers Inn (New York)	1980	26
Thomas (San Francisco)	1961	22	Hilton (Las Vegas)	1981	8 (252 inj)
Surfside (Atlantic City)	1963	25	Royal Beach (Chicago)	1981	19
Roosevelt (Jacksonville)	1963	22	Alexander Hamilton (N. J.)	1984	15

ENTERTAINMENT VENUES:

Structure	Date	# Fatalities	Structure	Date	# Fatalities
Richmond Theatre (Virginia)	1811	160	Circus (Connecticut)	1944	169(700+inj)
Brooklyn Theater (New York)	1876	295	Restaurant (Ohio)	1965	22
Theater (Chicago)	1903	602	Lounge (Gary, IN)	1968	13
Rhoads Theater (PA)	1908	170+	LA Cocktail Lounge (L.A.)	1973	32
Dance Hall (Louisiana)	1919	25	Social Club (New York)	1976	25
Dance Hall (Mississippi)	1940	207	Supper Club (Kentucky)	1977	167
Strand Theater (Massachusetts)	1941	13	Happy Land (New York)	1980	87
Nightclub (Massachusetts)	1942	492	The Station (Rhode Island)	2003	100

SCHOOLS:

Structure	Date	# Fatalities	Structure	Date	# Fatalities
Collinwood (Ohio)	1908	176	New London (Texas)	1937	295-500?
Peabody (Massachusetts)	1915	22	Cleveland (New York)	1954	15
Cleveland (South Carolina)	1923	77	Chicago (Illinois)	1958	93
Babbs Switch (Oklahoma)	1924	36	-	-	-

HEALTH CARE:

Structure	Date	# Fatalities	Structure	Date	# Fatalities
Hospital (Oklahoma)	1918	38	Nursing Home (Missouri)	1957	72
Manhattan State (New York)	1923	25	Hospital (Connecticut)	1961	16
Clinic (Ohio)	1925	125	Nursing Home (Ohio)	1963	63
Little Sisters of Poor (Pitt., PA)	1931	48	Nursing Home (Indiana)	1964	20
St. Anthony's Hospital (Illinois)	1949	77	Nursing Home (Ohio)	1970	31
Mercy Hospital (Iowa)	1950	41	Nursing Home (P.A.)	1971	15
Nussing Home (Florida)	1953	35	Mental Hospital (M.S.)	1978	15
Nursing Home (Missouri)	1956	12	Wayside (Missouri)	1979	25

INDUSTRIAL/ FACTORIES:

Structure	Date	# Fatalities	Structure	Date	# Fatalities
New York City (New York)	1911	146	Texas City (Texas)	1947	561
Pittsburgh (Pennsylvania)	1927	28	**Livonia (Michigan)**	**1953**	**6**
Los Angeles (California)	1947	15 (150+ inj)	Hamlet (North Carolina)	1991	25

PRISONS:

Structure	Date	# Fatalities	Structure	Date	# Fatalities
Columbus (Ohio)	1930	329	Jacksonville (Florida)	1967	37

Source: ***The Public Health Consequences of Disasters - 1989,*** U.S. Department of Health and Human Services; Lansing State Journal

December 24, 1913: Not an actual fire, but the threat of a fire caused the suffocation deaths of 73 persons (mostly children) in Calumet's Italian Hall when someone attending a party there yelled "Fire!", sending masses of party goers in a mad rush for the exit. Although there was no fire, 73 persons died while attempting to escape down a stairwell that had doors that opened inward. The perpetrator of the tragic false fire alarm was never identified.

A 1927 fire at the Briggs Manufacturing Plant in Detroit resulted in 21 deaths. A 1934 fire at the Kerns Hotel in downtown Lansing killed 34 and injured 40.

February 8, 1951: Although it did not result in any loss of life, the arson fire at the State Office Building in Lansing was another significant structural fire that had a profound impact on Michigan. That fire, which caused close to $7 million in damage and burned for a week—destroyed thousands of irreplaceable state records and archives, including the Michigan Library. The fire was started by a young employee who thought having a criminal record would prevent him from being drafted into the Korean War.

August 2005: Another example of a catastrophic fire that did not result in any loss of human life is the blaze at a poultry farm in Berlin Township, Ionia County. The fire destroyed an egg-production building at one of the state's largest poultry farms, causing the death of over 250,000 chickens and $5 million in damage. Sixteen fire departments from four counties responded to the fire that destroyed the 150-by 600-foot building, which housed egg-laying hens.

Urban Conflagrations

It seems important to mention some of the major historical fires that have been so destructive to cities in the past, because many historical sections of Michigan's current cities remain at risk, due to their development densities and original designs that would not meet current construction and fire safety requirements. Events such as the Great Chicago 1871 fire, San Francisco's 1906 earthquake-related conflagration, and others should serve as reminders that older sections of cities may be more vulnerable to the spread of structural fires.

The following list refers to significant structural fires in Michigan communities, especially those that affected major facilities or downtown business districts, caused tremendous physical damage, death, loss of tax base due to business closures, and negatively impacted other important aspects of those communities.

Additional major urban conflagrations or significant structural fire events in Michigan

6/11/1805 Detroit (Wayne County)
All but one of the town's 300 buildings were destroyed. Territorial governor William Hull then authorized the 1807 plan of Detroit, with a less compact and crowded urban design less amenable to catastrophic fires—a kind of hazard mitigation planning.

5/10/1848 Detroit (Wayne County)
A fire broke out in Detroit that destroyed 107 buildings, including two large warehouses on the river. The burnt district covered over 10 acres of ground. Damage estimates were between $200,000 and $300,000. The number of families deprived of houses was about 200, or nearly 1000 persons.

7/31/1874 Muskegon (Muskegon County)
A fire destroyed a quarter of the business district and about 200 homes.

6/11/1881 Ludington (Mason County)
A fire destroyed almost the entire downtown (67 buildings).

8/5/1881 "Great Thumb Fire"
Nearly all, if not all of the entire buildings were destroyed in towns from the Michigan "thumb" counties of Huron, Tuscola, and Sanilac. Many Lapeer County buildings were also destroyed. 282 people lost their lives and damage was over $2 million. Over one million acres were burned, and this was also the first disaster served by the American Red Cross.

1/18/1884 Lowell (Kent County)
20 downtown buildings were destroyed by a fire.

9/17/1887 Ironwood (Gogebic County)
Over half of the downtown's buildings were destroyed by a fire.

12/22/1888 Hermansville (Menominee County)
A fire destroyed the entire town of more than 400 population, causing over $250,000 in damage.

5/16/1891 Muskegon (Muskegon County)
A fire destroyed about 250 buildings and homes, including the court house.

7/25/1892 Bay City (Bay County)
A fire destroyed nearly 350 homes and businesses in a 40 block area, resulting in around 1,800 people going homeless. Strong gale force winds along with the burning of timber-constructed structures contributed to the great spread.

6/28/1893 Augusta (Kalamazoo County)
Nearly the entire village of Augusta, with a population of at least 600, was destroyed.

11/24/1893 Detroit (Wayne County)
One building was destroyed and several buildings were damaged in a fire that caused 8 fatalities and about $700,000 in damage.

7/5/1897 Lake Ann (Benzie County)
A fire destroyed all but one building in a village of about 1,000 people.

5/10/1900 Fruitport (Ottawa/Muskegon Counties)
A fire wiped out over half of the downtown business district.

5/15/1901 Detroit (Wayne County)
Several buildings were destroyed in a fire, resulting in about $1,000,000 in damages.

7/5/1908 Kalkaska (Kalkaska County)
Nearly the entire town was wiped out by a fire.

12/9/1909 Kalamazoo (Kalamazoo County)
Several buildings were destroyed in a fire, resulting in about $1,000,000 in damages.

4/3/1910 Rose City (Ogemaw County)
A fire destroyed the entire town of more than 30 buildings, except for two concrete structures which were able to endure.

7/11/1911 Oscoda—Au Sable (Iosco County)
A fire destroyed about 600 buildings in the Oscoda and Au Sable area, resulting in five fatalities.

7/6/1913 Perry (Shiawassee County)
A disastrous fire consumed nearly the whole downtown area.

10/21/1930 Dewitt (Clinton County)
A fire destroyed the downtown business district and several historic buildings.

1/24/1938 Marquette (Marquette County)
A fire destroyed downtown buildings during a snow blizzard, resulting in $400,000 in damages.

3/17/1951 Owosso (Shiawassee County)
One large industrial factory was destroyed, resulting in $2,000,000 in damages.

2/20/1954 Hartford (Van Buren County)
One senior citizen home was destroyed, resulting in seven fatalities.

2/11/1955 Owosso (Shiawassee County)
One large industrial factory was destroyed, resulting in $2,500,000 in damages.

1/2/1958 Lowell (Kent County)
Seven businesses were destroyed in a massive fire.

7/23-30/1967 Detroit (Wayne County)
One of the most infamous riots ever in the United States occurred in Detroit from July 23-30, 1967, resulting in over 2,500 buildings damaged. This uprising resulted in the greatest loss of life and the largest destruction of property of any of the national riots of the 1960s. Over 7,000 arrests were made, 43 people were killed, and over 1,000 were injured. Many stores and buildings were set on fire during the riot, as much as six to seven miles out from the initial starting point. Over 150 fires consumed a 15 block area and burned uncontrolled when firefighters were forced to withdraw after being pelted by objects. About 5,000 were left homeless and over 400 structures were burnt or damaged enough to be demolished. Over $50 million in damage had been incurred, due to fires and looting.

10/29-31/1984 Detroit (Wayne County) (Note: the event occurred annually but with varying severity)
The Halloween tradition known as “Devil’s Night” reached its peak destruction level as 810 fires were intentionally set over a three day period in late October, in Detroit. The arson destruction during this time period had roots dating back to the 1930s, and it was very common to have hundreds of fires each year before Halloween. In the late 1990s city of officials created “Angel’s Night” where volunteers and law enforcement officials patrol neighborhoods and monitor abandoned buildings, generally starting the night of October 29.

2/8/1987 St. Johns (Clinton County)
One business was destroyed and resulted in $350,000 in damage.

2/10/1987 Ithaca (Gratiot County)
Four businesses were destroyed and two others were damaged, with total losses estimated at $750,000.

3/6/1987 Ovid (Clinton County)
Three businesses were destroyed, resulting in about $175,000 in damages.

3/13/1987 Detroit (Wayne County)
Two industrial buildings were destroyed, causing three fatalities and six other injuries.

1/26/1988 Alma (Gratiot County)
One business was destroyed, one person died, and total damages were about $150,000.

3/2/1988 Webberville (Ingham County)
One business was destroyed, along with the public library, resulting in about $200,000 in damage.

6/2/1988 Corunna (Shiawassee County)
Four businesses were destroyed and one other was damaged, resulting in total losses of about $2.4 million.
11/8/1990 Ovid (Clinton County)
One business was destroyed and one other was damaged, resulting in total losses of about $100,000.
1/20/1991 Perry (Shiawassee County)
One business was destroyed and three others were damaged, resulting in total losses of about $225,000.
2/28/1993 Ludington (Mason County)
Two apartment complexes were damaged, causing nine fatalities and $50,000 in damage.
6/1/1993 Owosso (Shiawassee County)
One factory was destroyed, totaling about $30,000,000 in damage.
7/18/1993 Grand Ledge (Eaton County)
Three businesses were destroyed and four others were damaged, totaling about $525,000 in losses.
4/25/1995 Flint (Genesee County)
One business was destroyed, causing more than $1,000,000 in damage.
6/26/1999 Suttons Bay (Leelanau County)
One business was destroyed, resulting in damages estimated from $700,000 to $1,000,000.
11/10/1999 Flint (Genesee County)
One convalescent home was destroyed, resulting in five fatalities.
12/1/2000 Detroit (Wayne County)
One apartment complex was damaged, and six fatalities were reported from the fire.
4/2/2001 Detroit (Wayne County)
One 50-unit apartment complex was completely destroyed. Three injuries resulted.
4/30/2001 Wixom (Oakland County)
One apartment complex was destroyed.
5/25/2001 Detroit (Wayne County)
Five buildings were destroyed.
6/1/2001 Highland Park (Wayne County)
Three houses, two buildings, and one apartment were damaged.
7/3/2001 Detroit (Wayne County)
One large downtown building was destroyed by fire, and nearby buildings were threatened.
8/26/2001 Detroit (Wayne County)
One industrial building was destroyed and nine persons were injured.
4/16/2002 Detroit (Wayne County)
One apartment complex was destroyed, resulting in two injuries and more than 100 persons left homeless.
5/20/2002 Detroit (Wayne County)
One apartment complex was destroyed, leaving dozens homeless.
7/5/2003 West Bloomfield (Oakland County)
One building was destroyed, resulting in $2,500,000 in damages.
7/24/2003 Ann Arbor (Washtenaw County)
Four buildings were destroyed.
8/18/2003 Inkster (Wayne County)
An 18-unit apartment complex was destroyed, resulting in one injury.
9/22/2003 Detroit (Wayne County)
A natural gas explosion blew up a vacant home and caused two occupied homes to catch on fire. Up to 30 nearby homes may have been damaged by debris.
12/29/2003 Detroit (Wayne County)
A 34-unit apartment complex was destroyed, resulting in one injury.
1/6/2004 Grosse Pointe (Wayne County)
Three businesses were destroyed, along with six apartment units.
1/20/2004 Springfield Twp. (Oakland County)
One building was destroyed, along with eight salt trucks and seven graders.
3/4/2004 Lake Orion (Oakland County)
Six businesses were destroyed, some of which had dated back to the 19th century.
8/24/2004 Southfield (Oakland County)
One apartment complex was destroyed, but its residents were safely evacuated.
5/13/2005 Highland Park (Wayne County)
A block fire involved several houses being burned. Evidence pointed to its being set by an arsonist.
6/20/2005 Detroit (Wayne County)
A large but vacant industrial plant was destroyed. The incident involved 150 responders and caused three injuries.

7/12/2005 Detroit (Wayne County)
Six units in apartment complex were destroyed and six units were damaged.
8/10/2005 Ionia (Ionia County)
One large and densely populated livestock building was destroyed, causing $3,000,000 in damage, and 250,000 chickens to be killed in the fire.
9/13/2005 Hartford (Van Buren County)
One business was destroyed, and one apartment complex was damaged.
9/23/2005 Utica (Macomb County)
One historic building was destroyed.
10/16/2005 Detroit (Wayne County)
A large but vacant industrial building was destroyed by fire.
3/3/2006 Ann Arbor (Washtenaw County)
An apartment complex was damaged, causing one fatality, two injuries, and more than persons to be evacuated.
5/23/2006 Bay City (Bay County)
One 8-unit apartment building was destroyed, along with several shops.
12/7/2006 Detroit (Wayne County)
One apartment complex was destroyed, causing one fatality and leaving 51 families homeless.
2/8/2007 Ypsilanti (Washtenaw County)
One apartment complex was damaged, destroying six of its units and causing three fatalities.
3/7/2007 Cedar Springs (Kent County)
Fire devastates homes and businesses in the downtown area.
5/7/2007 Millersburg (Presque Isle County)
Five buildings used by a single industry were destroyed in Millersburg.
5/18/2007 Linden (Genesee County)
Three businesses were destroyed.
7/4/2007 Owosso (Shiawassee County)
An apartment complex was destroyed, causing one fatality, and two businesses were damaged.
9/16/2007 Mount Pleasant (Isabella County)
Three businesses were destroyed.
1/20/2008 Grand Rapids (Kent County)
Two buildings were destroyed, involving more than 100 destroyed condominiums and the evacuation of over 200 persons.
1/23/2008 Van Buren Twp. (Wayne County)
One 32-unit apartment building was destroyed.
2/6/2008 Detroit (Wayne County)
One apartment complex was destroyed, leaving more than 100 persons homeless and causing one death and two injuries.
4/3/2008 Bay City (Bay County)
One 18-unit apartment building was destroyed.
6/17/2008 Mount Clemens (Macomb County)
10 apartment units were destroyed in an apartment complex fire.
8/31/2008 Ontonagon (Ontonagon County)
Seven buildings were destroyed resulting in $250,000 in damages.
8/21/2008 Harrison Township (Macomb County)
One 37-unit apartment complex was destroyed.
10/2/2008 Clare (Clare County)
One business was destroyed in a large fire, and the downtown area was evacuated.
12/10/2008 Shepherd (Isabella County)
One business was destroyed in a large fire that also impacted emergency responders.
2/3/2009 Kalamazoo (Kalamazoo County)
One 36-unit apartment complex was destroyed.
2/13/2009 Fenton (Genesee County)
One 18-unit apartment complex was destroyed.
3/7/2009 Cedar Springs (Kent County)
Three businesses and two apartments were destroyed.
5/20/2009 Marquette County (Marquette County)
33 structures were destroyed by wildfire, and more than 500 persons were evacuated.
6/30/2009 Muskegon (Muskegon County)
One 10-unit apartment complex was destroyed, causing five injuries.
7/25/2009 Hancock (Houghton County)
One building was destroyed, and two apartment floors were destroyed by fire, resulting in four fatalities.

8/5/2009 Big Rapids (Mecosta County)
One business was destroyed, resulting in $4,000,000 in damages.
10/25/2009 Ann Arbor (Washtenaw County)
One business was destroyed and four apartments were damaged. More than 600 persons were evacuated during the event.
1/22/2010 Grand Blanc (Genesee County)
One 24-unit apartment complex was destroyed.
1/30/2010 Potterville (Eaton County)
Four businesses were destroyed.
3/19/2010 Wyoming (Kent County)
A fire destroyed a 32 unit apartment complex, displacing all 30 residents.
5/17/2010 Homer (Calhoun County)
An historic 19th-Century community mill was destroyed by fire.
5/19/2010 Gaylord (Otsego County)
One business was destroyed by fire, which also caused three businesses and two apartment complexes to be damaged.
9/7/2010 Detroit (Wayne County)
At least 85 fires destroyed more than 70 homes in Detroit, propelled by strong winds gusting up to 40-50mph, and exacerbated by hot and dry conditions, downed power lines, and a shortage of equipment and manpower. The fires affected multiple neighborhoods throughout the city.
10/14/2010 Alma (Gratiot County)
Two businesses were destroyed, and four other businesses were damaged.
3/26/2011 Jackson (Jackson County)
A large 19th-Century large factory building was destroyed as a result of arson.
5/9/2011 Grand Rapids (Kent County)
One large factory building was destroyed.
6/24/2013 Plainwell (Allegan County)
An industrial building caught fire and required evacuation of persons for ¼ mile around, since the business was a major handler of hazardous materials in the midst of an industrial park. Explosions and thick smoke posed a threat to persons nearby, and more than 30 businesses in the industrial park were closed for at least a day or two, until the situation could be gotten under control.
11/12/2013 Lapeer (Lapeer County)
A fire in the historic downtown area destroyed several businesses and left 15 residents of apartments without their homes. Some limited damage from smoke and water affected a few of the surrounding structures that were otherwise saved by prompt and effective firefighting actions.
1/3/2014 Plainfield Township (Kent County)
A destructive fire broke out in one wing of the main building built into the Minor League baseball stadium for the West Michigan Whitecaps, an affiliate of the Detroit Tigers. A whole section of the building collapsed under the effects of the intense fire, but the stadium intends to rebuild it in time for the 2014 season.

Although structural fires occur every day in both large cities and small towns in Michigan, what was significant about these particular fires was the level of impact they had on the communities. In some cases, the very lifeblood of the community's business and retail districts was destroyed or severely damaged, affecting not only the structures themselves, but also the community's economy as well. Some of the affected businesses never re-opened. (Note: please refer also to the section on Wildfires, for more information about some of these events.)

College Dormitory Fire Safety

The fire safety of college dormitories across the country was called into question on January 19, 2000 when a predawn fire at a Seton Hall University (New Jersey) dormitory killed 3 students, injured 62, and forced the evacuation of hundreds more students into the freezing cold outside. The Seton Hall tragedy set off a national re-examination of fire safety measures and practices in dormitories and similar congregate housing facilities at colleges and universities. Sensing the need for additional financing of fire safety measures on college campuses, Congress occasionally considers legislation that would authorize appropriations for nationwide competitive grants to help provide fire sprinkler systems in student housing and dormitories.

In Michigan, fires in two college dormitories in March of 2000 provided a reminder that what happened at Seton Hall University in New Jersey could also happen here given the right circumstances. On March 16, an early-morning fire at a Western Michigan University dormitory in Kalamazoo destroyed a first-floor room and forced the evacuation of more than 400 students. No one was injured in that fire. Three days later, on March 19, a fire in a third floor room at a 175-student Ferris State University dormitory hospitalized one person and left two others with minor injuries. The building's second and third floors sustained extensive fire and water damage.

Michigan colleges do have a history of significant fire incidents, such as in 1986 when 34 students were injured in a Michigan State University dorm fire. Also, on March 9th, 1989 a massive fire gutted 50 percent of Sherzer Hall at Eastern Michigan University. It was classified as one of the most devastating events in the University's history.

In 1998/99, state, local and university officials in Michigan had already begun to take a closer look at the fire safety standards and requirements for Michigan's college and university dormitories. That re-examination resulted in the adoption of new fire safety rules that took effect in December 1999. (See the Programs and Initiatives section below for more details.) Below is a chart showing the statistics of U.S. dormitory fires from 1980-2006. It should be noted that dormitories include school, college and university dormitories; nurses' quarters; convent, monastery and other religious dormitories; and bunk houses and worker's barracks.

U.S. Dormitory Fires: 1980-2006

Year	Fires	Civilian Deaths	Civilian Injuries	Property Damage (in millions)
1980	3,200	13	122	$9.2
1981	2,960	4	118	$12.6
1982	2,420	0	103	$9.4
1983	2,490	9	156	$23.9
1984	2,510	5	50	$11.1
1985	2,440	0	68	$7.8
1986	2,350	5	55	$46.9
1987	2,560	0	76	$10.5
1988	2,430	3	91	$8.1
1989	2,650	0	109	$17.4
1990	2,330	2	80	$24.5
1991	2,270	8	61	$37.1
1992	2,470	2	147	$7.4
1993	2,270	0	73	$8.8
1994	2,320	0	75	$12.6
1995	2,330	0	143	$20.3
1996	2,050	0	78	$10.2
1997	2,200	9	73	$12.2
1998	1,810	5	143	$9.7
1999	1,380	0	190	$5.0
2000	1,780	7	168	$23.0
2001	2,940	6	67	$104.0
2002	3,110	1	19	$20.0
2003	3,350	1	50	$23.0
2004	3,380	3	48	$18.0
2005	3,270	1	59	$37.0
2006	4,290	2	58	$40.0

Source: National Fire Incident Reporting System

State Facility Fire Safety

A February 1999 fire in the G. Mennen Williams Building in Lansing (which houses the Michigan Department of Attorney General) caused $4.2 million in damage and forced the temporary relocation of many employees. The fire is believed to have started in a photocopy machine. Fortunately, the fire occurred over the Presidents Day holiday when the building was mostly vacant, so no injuries occurred. The Williams Building, like many state facilities, was built before sprinkler systems were routinely recommended as a fire safety measure. As a result of this fire, the State Fire Safety Board of the Michigan Department of Licensing and Regulatory Affairs is considering adopting stricter fire safety standards for all state owned and leased facilities—including the installation of fire sprinkler systems in all new facilities and those undergoing major renovation.

A December 22, 2001 fire at the Murray D. Van Wagoner Building in Lansing (which houses the Michigan Department of Transportation) severely damaged the third floor, causing smoke and water damage throughout all of the building's four floors. Fortunately, the building was empty at the time the fire occurred. The fire forced the temporary relocation of several hundred workers until the building could be cleaned up and restored.

Programs and Initiatives

Michigan Fire Prevention Act

The Michigan Fire Prevention Act (1941 PA 207), the State's primary fire enabling legislation, provides for the prevention of fires and the protection of persons and property from exposure to the dangers of fire and explosion. The Act gives the State Fire Marshal (Michigan Department of Licensing and Regulatory Affairs) and local fire chiefs broad authority to take actions necessary to prevent fires and stop the spread of fires once they have started. This includes: 1) requiring the razing, repair, alteration or improvement of buildings and premises that constitute a fire hazard; 2) controlling the use and occupancy of such buildings and premises; and 3) engaging in public education activities aimed at preventing or mitigating the effects of fire and explosion.

Michigan Department of Licensing and Regulatory Affairs, Michigan Fire Fighters Training Council

The Michigan Fire Fighters Training Council, housed within the Michigan Department of Licensing and Regulatory Affairs, performs a number of tasks aimed at developing, improving, and enhancing the training of fire fighters in Michigan. This includes, but is not limited to: 1) developing standards for training and fire fighter selection; 2) establishing courses of study and instructor qualifications and certification; 3) evaluating instructors and schools; and 4) assisting fire departments with training. All of these functions contribute to structural fire mitigation by enhancing the skills of fire fighters in preventing and suppressing fires.

The Michigan Department of Licensing and Regulatory Affairs, in conjunction with local fire departments, conducts a number of other important fire-related initiatives, including: 1) statewide public education programs aimed at preventing fires; 2) investigating fires, explosions and hazardous material incidents; and 3) collecting, compiling and analyzing fire-related data (through the National Fire Incident Reporting System) to determine fire frequency, causes, and impacts; 4) membership association and union membership organization for both fire fighters and fire chiefs.

Michigan's Office of Fire Safety

The Michigan Department of Licensing and Regulatory Affairs' Office of Fire Safety is responsible for conducting fire safety and prevention inspections in state-regulated facilities and certain other facilities. Specific services provided include: 1) fire safety inspections of adult foster care, correctional and health care facilities, and hotels/motels; 2) plan review and construction inspections of the regulated facilities in item (1), as well as schools, colleges, universities, and school dormitories; 3) coordination of fire inspector training programs; and 4) coordination of fire alarm and fire suppression system installation in regulated facilities. These activities are important mitigation activities designed to save lives and protect property from structural fire hazards. The State Fire Safety Board, also housed within the Michigan Department of Licensing and Regulatory Affairs, Bureau of Construction Codes and Fire Safety, promulgates rules covering the construction, operation and maintenance of schools, dormitories, health care facilities, and correctional facilities. These rules are designed to protect life and property at these facilities from fire, smoke, hazardous materials and fire-related panic.

National Fire Protection Association

Established in 1896, the National Fire Protection Association (NFPA) conducts research on fires and fire-related issues, develops codes and standards for fire prevention and protection, and disseminates fire safety information to fire departments and the public. The cornerstone of the NFPA's fire prevention activities is its consensus standards development system. The NFPA's consensus process involves over 6,000 volunteers from a wide range of professional backgrounds who serve on more than 200 technical committees, each reflecting a balance of affected interests. This consensus standards development system resulted in the creation and maintenance of the

National Fire Codes, over 300 codes and standards covering all areas of fire safety. Used throughout the world, virtually every building and construction process in place today is affected, in one way or another, by the codes and standards developed through the NFPA system. Even when not written into law, the Association's standards and codes are typically accepted as a professional standard, and are recognized by many courts as such. The NFPA codes and standards help to reduce the structural fire threat in Michigan, and elsewhere.

U.S. Fire Administration

Established by P.L. 93-498, the Federal Fire Prevention and Control Act of 1974, the U.S. Fire Administration (USFA) provides leadership, coordination and support for the nation's fire prevention and control, fire training and education, and emergency medical services activities. The USFA, a branch of the federal Department of Homeland Security, conducts training for firefighters through the National Fire Academy (NFA), located in Emmitsburg, Maryland. Many Michigan firefighters have attended those training courses. In addition, the USFA administers a number of national fire programs aimed at fire prevention, with a particular emphasis on structural fire prevention. The USFA also supports the National Fire Incident Reporting System (NFIRS), administered and implemented in Michigan by the State Fire Marshal (Department of Licensing and Regulatory Affairs). The NFIRS provides the vehicle for collecting and analyzing information on fire frequency and causes, as well as deaths, injuries and property losses associated with fires. Over 900 local fire departments in Michigan participate in the NFIRS. The NFIRS data is used by the State Fire Marshal and other state and local fire agencies to assess and combat the fire problem in Michigan.

Local Fire Service

Over 1,000 local fire departments and roughly 30-35,000 fire fighters constitute the bulk of Michigan's fire service forces. By and large, these local forces are either volunteers or paid part-time (approximately 56% paid part-time; 16% volunteer; 28% paid full-time). According to statistics from the State Fire Marshal, local fire departments in Michigan respond to a fire call, on average, every minute and 17 seconds, and to a structural fire call roughly every 28 minutes. In addition to fire suppression, local fire departments in Michigan also conduct vitally important public education, code enforcement and fire investigation activities within their respective communities. Local fire departments are the lifeblood of Michigan's fire prevention and suppression system.

The Hotel and Motel Fire Safety Act of 1990 (PL101-391)

The Hotel and Motel Fire Safety Act of 1990 was passed into law by Congress to save lives and protect property by promoting fire and life safety in hotels, motels and other places of public accommodation. The law mandates that traveling federal employees must stay in public accommodations that adhere to the life safety requirements in the legislation's guidelines. PL101-391 also states that federally funded meetings and conferences cannot be held in properties that do not comply with the law. The United States Fire Administration (USFA) has been charged with carrying out FEMA's responsibilities with respect to the Hotel and Motel Fire Safety Act of 1990. In addition to compiling, maintaining and publishing the National Master List, the USFA is also responsible for taking steps to encourage states to promote the use of automatic sprinkler systems and automatic smoke detection systems.

Fire Safety Rules for Michigan Dormitories

Even before the Seton Hall University dormitory fire in January, 2000, the State Fire Safety Board took action to enhance the fire and life safety protection of Michigan's college and university dormitories. On December 21, 1999 two new sets of rules took effect governing the construction, operation, and maintenance of school, college and university instructional facilities and dormitories. These sets of rules were updated to meet the most current nationally recognized standards from the National Fire Protection Association. The new rules adopted the 1997 edition of NFPA 101, Life Safety Code. NFPA standards provide the minimum requirements necessary to establish a reasonable level of fire and life safety and property protection from hazards created by fire and explosion.

The new rules require, among other things, that fire sprinklers be installed in newly constructed dormitories or those undergoing major renovations. However, existing dormitories don't fall under the new rules and therefore do not have to be retrofitted unless they are being renovated.

U.S Fire Corps

In 2002, President George W. Bush announced the creation of the USA Freedom Corps, which is an effort to foster a culture of service, citizenship, and responsibility, building on the generous spirit of the American people. One of the initiatives of USA Freedom Corps is Citizen Corps. Citizen Corps programs share the common goal of helping communities prevent, prepare for, and respond to natural disasters, and other emergencies, at various levels of government. One of the Citizen Corps partner programs is Fire Corps. This program is a partnership between the International Association of Fire Chiefs' Volunteer Combination Officers Section (VCOS), the International Association of Fire Fighters (IAFF), the National Volunteer Fire Council (NVFC), and the White House's USA Freedom Corps Office. The program's ultimate goal is to support and supplement resource-constrained fire departments at all levels, volunteer, combination, and career. This will be accomplished through the use of civilian advocates for non-operational related activities. The program will educate fire departments on how to implement a non-operational citizen advocates program, or improve existing programs. Fire service input to the program is provided through the Fire Corps National Advisory Committee which gives strategic direction and important feedback from the field to Fire Corps.

Michigan Fire Service Coalition

Various websites provide services regarding information, training and news about issues within fire services in Michigan. In October 2005, the Michigan Professional Fire Fighters Union, the Michigan Fire Inspectors Society, the Michigan Fire Service Instructors, the Michigan Association of Fire Chiefs and the Michigan State Firemen's Association united to form the Michigan Fire Service Coalition. Michiganfireservice.com is a site dedicated to the men and women who serve throughout the State as fire fighters, company officers, fire chiefs, fire marshals, training instructors, or permit technicians. The site intends to provide quality information about fire service news, training, and issues that affect Michigan's Fire Service. Michigan Safety News is a similar site for safety professionals across Michigan to discuss contemporary safety issues as a discussion forum to share ideas on success, lend expertise, ask questions, discuss contemporary issues and monitor important news.

Michigan Fire Inspectors Society (www.mfis.org) is a code-related organization in the State of Michigan. With almost 600 members, the organization represents the wide interests of Michigan's Fire Inspectors. Committees include members serving to provide updated rules or to monitor code changes. MFIS works to educate members on current trends and practices at conferences which include the fall educational seminar and winter educational conference. The Michigan Association of Fire Chiefs provides leadership and a voice for the fire service and its providers to government residents, fire service members, and other organizations, to protect and improve the safety of Michigan residents.

Hazard Mitigation Alternatives for Structural Fires

- Code existence and enforcement.
- Designs that include the use of firewalls and sprinkler systems (especially in tall buildings, dormitories, attached structures, and special facilities).
- Landlords and families can install and maintain smoke detectors and fire extinguishers. Install a smoke alarm on each level of homes (to be tested monthly, with the batteries changed twice each year). Family members and residents should know how to use a fire extinguisher.
- Proper installation and maintenance of heating systems (especially those requiring regular cleaning, those using hand-loaded fuels such as wood, or using concentrated fuels such as liquid propane).
- Safe use and maintenance/cleaning of fireplaces and chimneys (with the use of spark arresters and proper storage of flammable items). Residents should inspect chimneys at least twice a year and clean them at least once a year.

- Safe installation, maintenance, and use of electrical outlets and wiring.
- Measures to reduce urban blight and associated arson (possibly including Crime Prevention through Environmental Design).
- Defensible space around structures in fire-prone wildland areas.
- Proper maintenance of power lines, and efficient response to fallen power lines.
- Transportation planning that provides roads, overpasses, etc. to maximize access and improve emergency response times to all inhabited or developed areas of a community. (Not just planning for average traffic volumes in the community.)
- Discourage civil disturbances and criminal activities that could lead to arson.
- Enforced fireworks regulations.
- Elimination of clandestine methamphetamine laboratories through law enforcement and public education.
- Condominium-type associations for maintaining safety in attached housing/building units or multi-unit structures.
- Obtaining insurance.

Tie-in with Local Hazard Mitigation Planning

Because many means of implementing mitigation actions occur through local activities, this updated MHMP places additional emphasis on the coordination of State-level planning and initiatives with those taking place at the local level. This takes two forms:

1. The provision of guidance, encouragement, and incentives to local governments by the State, to promote local plan development, and
2. The consideration of information contained in local hazard mitigation plans when developing State plans and mitigation priorities.

Regarding the first type of State-local planning coordination, MSP guidance has included the "Local Hazard Mitigation Planning Workbook" (EMD-PUB 207), which is currently being updated for release by 2015. For the second type of State-local planning coordination, a section later in this plan summarizes hazard priority information as it has been reported in local hazard mitigation plans. Here, it will merely be noted that structural fires were identified as one of the most significant hazards in local hazard mitigation plans for the following counties: Gratiot, Hillsdale, Huron, Jackson, Ontonagon, and Saginaw.

SCRAP TIRE FIRES

A large fire that burns scrap tires being stored for recycling or re-use.

Hazard Description and Analysis

With the disposal of an estimated 290 million vehicle tires annually in the United States, management of scrap tires has become a major economic and environmental issue. Michigan generates approximately 10 million scrap tires each year. Although responsible means of storage and disposal have become more common, tire dumps of the last forty years still present environmental and safety hazards. In May 2012, the State of Michigan identified 55 non-compliant scrap tire collection sites containing a total of about 550,000 tire equivalents (unburied ones that pose the greatest fire danger) in outdoor stockpiles scattered around the state. Since the MDEQ Michigan Scrap Tire Program began in 1991, the total amount of Michigan's scrap tire stockpile has gone from 31 million down to about 2.2 million. The department estimates that most of the remaining tires could be disposed of before the end date of the program's funding in December 2015.

Scrap Tire Disposal Sites in Michigan: November 2009

County	Sites	Tires	County	Sites	Tires
Alpena	2	100,250	Livingston	1	1,000
Arenac	1	37,341	Marquette	1	3,000
Bay	1	700	Mecosta	1	8,000
Benzie	1	10,000	Menominee	1	2,000
Calhoun	2	5,700	Midland	2	121,100
Cass	1	37,000	Monroe	2	7,500
Chippewa	1	500	Montcalm	1	2,000
Clare	1	700	Newaygo	2	27,000
Crawford	1	10,000	Oakland	2	20,633
Dickinson	1	499	Oceana	1	11,000
Eaton	1	300	Osceola	2	2,385,000
Genesee	2	152,000	Ottawa	1	100,000
Grand Traverse	1	1,499	St. Clair	3	9,400
Gratiot	1	2,500	St. Joseph	2	48,000
Hillsdale	1	1,300	Sanilac	2	11,000
Houghton	2	117,500	Shiawassee	1	1,000
Ingham	1	500	Tuscola	2	12,700
Iosco	1	4,800	Wayne	22	168,977
Ionia	1	3,000	Van Buren	2	3,000
Jackson	2	6,600	**Total**	76	3,435,499

Source: Department of Environmental Quality, Waste and Hazardous Materials Division.

NOTE: Inventory totals compiled for tire quantities are approximated and will vary from year to year, as new tires are brought in and others are recycled or otherwise disposed of.

Issues pertaining to the management of scrap tire disposal sites are difficult and diverse. Whole tires are difficult to landfill because they tend to float to the surface. Whole tires are banned from disposal in Michigan landfills due to their associated problems. Scrap tires are breeding grounds for mosquitoes, which can reproduce at thousands of times their natural rate in a scrap tire disposal site, and these mosquitoes can carry and transmit life-threatening diseases. Stockpiles also are home to snakes and small mammals such as rats, opossums, skunks, and raccoons. Stockpiled tires are often soiled with mud, dirt, or other foreign materials that limit potential markets and increase processing costs. From an emergency management perspective, the most serious problem that scrap tire disposal sites pose is that they can be a tremendous fire hazard if not properly designed and managed.

Rather than causing structural damages and loss of life, the majority of the costs of a scrap tire fire are economic and environmental. A scrap tire fire may require the temporary evacuation of some residences and businesses, and the closure of some roadways—all of which have calculable costs. The biggest headache for a community

may be the difficulty in controlling and extinguishing these fires, which can occupy emergency responders for days! For example, a 1997 fire in Osceola County cost about $300,000 to extinguish, and used 478 firefighters from 34 different departments. Such costs can be extremely demanding on rural counties that generally have limited resources. Tire disposal sites can be serious fire hazards due to the sheer number of tires typically present at a site. This large quantity of "fuel," coupled with the fact that the shape of a tire allows air to flow into the interior of a large tire pile, renders standard firefighting practices nearly useless. Flowing burning oil released by the tires spreads the fire to adjacent areas. Some scrap tire fires have burned for months, creating acrid smoke and an oily residue that can leach into the soil, creating long-term environmental problems.

Deep stockpiles of compacted tire shreds can undergo a progressive series of exothermic reactions that increase pile temperatures and generate combustible gases. Surface symptoms of this phenomenon can be subtle, such as a slight sulfur odor, vapor steaming from isolated sections of the pile surface, or a slight oil sheen on adjacent standing water after rainfall. Due to the potential for auto-ignition, surface fires can ignite on a shredded tire stockpile, especially as shreds are removed from the area near the hot zone. Gases and shreds are then exposed to air and may ignite.

Scrap tire fires differ from conventional fires in several respects: 1) even relatively small scrap tire fires can require significant resources to control and extinguish; 2) the costs of fire management are often far beyond that which local government can absorb; 3) the environmental consequences of a major tire fire are significant; and 4) as alluded to earlier, the extreme heat converts a standard passenger vehicle tire into about two gallons of oily residue, which can leach into the soil or drain into streams.

Current technologies are sufficient to address the reuse of newly generated scrap tires, but some waste tires still migrate to the least expensive disposal method, which usually means they end up in a scrap tire disposal site (sometimes illegally). Lightning strikes, equipment overheating or sparks, unattended burning of debris/refuse, and arson are the leading causes of tire fires. Fires are also sometimes started by site operators or local residents in the wake of publicity over clean-up activities. This publicity can include enforcement proceedings or initial abatement activities, suggesting that a landowner may be acting out of frustration or attempting to avoid costs associated with tire abatement.

Much work still needs to be done to mitigate the impacts of scrap tire fires. Incident management planning, recognition of the hazardous material potential of fires at scrap tire sites, and improving and enhancing disposal site selection and design processes are all critical pre-incident preparedness factors that must be addressed by government and the private sector. In light of the potential consequences of scrap tire fires, prevention must become a primary goal in the treatment of scrap tire disposal sites. The Rubber Manufacturers Association has put together a document on the Prevention and Management of Scrap Tire Fires that can be printed and used by local fire officials. This document can be found at: http://www.rma.org/scrap_tires /scrap_tires_ and the_ environment/fireprevention.cfm.

Impact on the Public

Scrap tire fires often involve extensive smoke and pollution that may prompt evacuations from, and lingering odors in, nearby residences. In addition to the disruption and inconvenience of even a temporary displacement (especially on the elderly, disabled, and very young), negative health effects may result from smoke exposure, and considerable time and expense may be involved in the process of cleaning and deodorizing homes afterward. Nearby local roads, businesses, and facilities may be closed during a fire event. Scrap tire piles also tend to serve as breeding grounds for mosquitoes, which cause additional health and nuisance problems for area residents.

Impact on Public Confidence in State Governance

Some of the public may have an idea that governmental regulations and environmental policy/enforcement should be able to entirely prevent scrap tire piles and fires from presenting a significant hazard. Scrap tire storage/disposal sites, plus any associated fires, can affect an area's property values, reputation, and environment. Local impacts from scrap tire sites should be viewed in terms of the larger-scale, specialized economic functions

being served by these sites and their associated businesses. Abstractions such as economic need/demand are not easy for all residents of an area to immediately understand and accept. The "not in my backyard" (NIMBY) problem is involved in this issue, for although tire disposal must occur (i.e. it is a necessary function) many residents see it as undesirable in their vicinity and would prefer that the service take place at a different location.

Impact on Responders

Scrap tire fires can involve excessive response costs and time/resource commitments that may strain local budgets and staff workloads. Responding personnel are exposed to unusually thick and toxic smoke from these events. Potential problems may also arise involving access to crowded or poorly-organized sites (tire sites with storage arrangements that didn't sufficiently conform to established regulations and restrictions).

Impact on the Environment

Stockpiles of tires may catch fire and the environmental consequences of a major tire fire include air, surface water, soil, groundwater, and residual contamination that have negative impacts on humans, wildlife, and natural vegetation. Scrap tire fires generate dense, black smoke containing partially combusted hydrocarbons. The smoke plume can negatively impact residences and businesses in its path as well as the air quality in a broad area for a significant time period. In addition to smoke, some tire fires produce large quantities of oils that contain hazardous compounds. Under certain conditions, these oils can penetrate porous soils to contaminate groundwater that is a source of the area's drinking water. The oils can also reach surface waters and cause substantial fish kills, due to the oils' depletion of dissolved oxygen levels. Finally, the residuals (ash, wire, and unburned rubber) from a tire fire often require special handling and disposal. Processing equipment can be damaged by handling heavily contaminated or partially burned tires, slowing the abatement process.

Significant Scrap Tire Fires

Scrap tire fires have occurred in Michigan in the past. Over the past several years, there has been a decrease in both the frequency and severity of fires at scrap tire disposal sites due to the cleanup of existing stockpiles and an increase in compliance at collection sites. Unfortunately, fire departments are generally ill-equipped and untrained to handle these incidents when they do occur. This is especially true in rural areas where many scrap tire disposal sites are located. Scrap tire fires occur often enough to present a major concern to those communities that have quantities of tires stored at disposal sites within or adjacent to their borders. Given the right set of circumstances, the potential is always there for a major fire that may require evacuation, sheltering, large amounts of fire suppression assistance, and both short and long-term environmental monitoring. Large scrap tire fires can also be very costly for the owner/operator and the affected local jurisdiction(s), as the fires are difficult to extinguish and typically require a large emergency response personnel presence at the fire scene (often for an extended period of time).

In recent history, the following incidents stand out as examples of the adverse impacts that can occur when fire breaks out at a scrap tire disposal site.

Significant Scrap Tire Fires in Michigan

October 30, 1987 – Kent County

A large fire broke out at a scrap tire disposal site in Kent County containing over one million tires. It was estimated that the blaze was contained to about a fifth of the ten-acre site and a fire break was established with bulldozers. Firefighters ultimately concluded that the best course of action was to allow the contained portion of the fire to burn, and that applying water would add no benefit. Nearby residents were evacuated during the early stages of the fire.

December 29, 1995 to January 20, 1996 – Grand Traverse County

A tire fire burned at a re-treading facility in Grawn near Traverse City. Initial fire response was delayed due to attempts by employees at the recycling center to extinguish the blaze without outside assistance. Over the course of the event, surrounding subdivisions were evacuated. The fire engulfed 100,000 tires spread over a three-acre site. Personnel from numerous area fire departments, as well as the U. S. Environmental Protection Agency (EPA) and U. S. Coast Guard, were involved in the containment and suppression effort. In all, 451 responders from 30 separate agencies assisted with the fire over its 22-day duration. The long duration of this fire was testimony to the difficulty of extinguishing fires of this nature.

July 30, 1996 – Clare County

A fire broke out at a scrap tire storage facility located in Redding Township in Clare County. Over the course of the fire, 14 fire departments responded, along with representatives from the EPA and Michigan Department of Environmental Quality (MDEQ). Fortunately, the fire was contained to 250,000 of the 4.2 million tires on the ten-acre site, and was extinguished the following day, some 32 hours after it began.

April 16, 1997 – Osceola County

The worst tire fire ever in Michigan occurred in Osceola County. The salvage yard where the blaze started contained over 6 million tires. All of the fire departments in a five county area were contacted. Residents within a three-mile radius were evacuated. The fire was extinguished in about two and one-half days by digging a trench around the perimeter of the fire to prevent its spread, and capping the fire with sand. In all, 478 firefighters from 34 different departments fought the blaze. The final cost of putting the fire out came to approximately $300,000. Over 1.5 million tires, two buildings and some trailers were lost in the fire.

March 26, 1998 – Monroe County

A grass fire spread to a scrap tire pile in London Township, setting fire to between 3,000 and 5,000 tires. The pile was 50'x 30' and about 6 to 10 feet high. Soil samples were obtained afterward, showing no signs of contamination and no surface or ground water effects. The fire was put out by local fire departments.

February 24, 2000 – Mecosta County

A fire broke out at a tire recycling plant located in Hinton Township in Mecosta County. The fire had started in a pole barn that contained approximately 50,000 shredded tires. Nearby structures that also contained scrap tires were in danger of catching fire as well. Approximately 150 fire personnel from 13 local fire departments fought the blaze. Eventually, sand was brought in by a local contracting firm to smother the flames. Investigators determined that the apparent cause of the fire was a machine that had caught fire earlier and had not been adequately extinguished. The fire had then spread from the machine to the tires.

October 31, 2000 – St. Joseph County

In the early morning hours, a fire broke out at a tire recycling plant located in Colon Township in St. Joseph County. The 250-foot diameter fire – apparently set by an arsonist – consumed approximately 10,000 of the 350,000 tires at the site. The tires were piled 20 feet high in some places, hindering fire suppression efforts. A total of 10 fire agencies assisted in containing the blaze. Local residents were advised to either evacuate the immediate area or close their doors and windows and stay indoors to avoid breathing the acrid, black, choking smoke from the fire. Although the site was located only 300 feet from the St. Joseph River, a dirt berm around the tire pile prevented runoff from the fire from contaminating the river. The fire was extinguished 12 hours after it had begun.

June 13, 2003 – Clare County

A large fire broke out at a scrap tire disposal site in Clare County. It was estimated that 135,000 of the 850,000 tires at the site had caught on fire. The fire response and pollution control efforts would have been much more difficult without the $250,000 in funds awarded to Clare County through the DEQ Scrap Tire Grant Program in 2002. The lanes constructed between the tire piles had bought firefighters enough time to prevent the fire from spreading into the remaining piles. Otherwise, they would have been dealing with a much larger fire. This fire occurred at the same location as the scrap tire fire of 1996, when 250,000 tires were involved.

August 5, 2004 – Ogemaw County

A fire occurred at an old junkyard where tires were in a pile 100 feet wide and 8 feet tall. The fire involved the tire pile and part of some adjacent woods. The fire was fought using water and foam, and by burying the burning tires with soil. The fire was extinguished after about 3 hours. The owner was issued a ticket for failing to control a fire he was using to burn brush and solid waste that had been intermingled with the tires.

August 17, 2005 – Wayne County

Three firefighters were injured while battling a tire fire early in the morning of August 17, 2005 in southwest Detroit. After a few hours, the fire was under control, but the tire sales and repair building was destroyed.

April 21, 2006 – Washtenaw County

A man was burning brush in a barrel at a salvage yard and then left the fire unattended to go eat lunch. While he was gone, a piece of burning wood fell on the ground, igniting a grass fire that spread to the tire pile. There were approximately 1,000-1,500 truck tires on the site—some on the ground and some in a semi-trailer. MDEQ staff suggested that the fire fighters try to limit the runoff from fire suppression activities at the site. The fire was put out with water and foam. The largest tire pile had been aflame, but the burning tires were quickly separated from the pile. Ash from the fire and partially burnt tires remained on the site.

January 24, 2008 – Saginaw County

A fire consumed an abandoned house and hundreds of scrap tires. 50 to 60 firefighters from the Watertown Township, Mayville, Caro, North Branch, Deerfield Township and Millington-Arbela fire departments worked for more than five hours to extinguish the flames and the smoldering embers, which had erupted just after noon. The fire destroyed the house and an attached garage while the burning tires created a lot of thick smoke. Bitter temperatures also caused the water run-off to freeze quickly, presenting an additional hazard for firefighters.

July 23, 2008 – Ottawa County

A scrap yard fire, fueled by 1,000 tires, kept fire departments from Spring Lake Township, Coopersville, Fruitport, Ferrysburg, Ottawa County, Marne and Grand Haven Township busy for several hours and sent thick plumes of black smoke over the area. This fire in Nunica was first reported at around 3:45 pm and was caused by sparks from workers who were cutting off an automobile's catalytic converter. The blaze was confined to roughly a 50-by-50-foot area. Because the nearest hydrant was about 2,000 feet away, water had to be trucked in. In all, 70,000 gallons of water were poured onto the fire before it was brought under control after 90 minutes. No structures were damaged by the fire and no injuries occured. Because of possible oil contamination from melting tires, the Department of Environmental Quality was notified.

September 9, 2009 – Kalkaska County

Hundreds of scrap tires were on fire in a wooded area of Springfield Township of Kalkaska County. Natural causes were considered to be unlikely. Despite the size of the area that was burning, a large crew had the area under control in about an hour. Police say the quick response saved several homes and minimized any health risks from the black smoke being generated.

June 11-13, 2010 – Ingham County

The Onondaga Township Fire Department responded to a tire fire inside a barn in the 4000 block of Gale Road. There were several hundred tires there, and the fire department had to respond 4 or 5 times as the fire burned for 3 days before finally being excavated and extinguished. Some of the tires were so old that they had wooden rims. The equivalent of 800 tires were found throughout the rest of the property, and the landowner was allowed to apply for a grant to have remaining tires cleaned up on his property for free.

December 31, 2010 – Muskegon County

An early morning fire destroyed a Twin Lake tire business on December 31, 2010 with damage estimates over $325,000. The fire started on the west end of a100-by-60 foot pole barn construction building. The building had several tires inside it which provided extra fuel for the fire after it started. City water was not available on the scene so responding fire crews set up water reservoirs at three sites and used tanker trucks to shuttle water in from other areas. A tanker task force involving 10 area fire departments was used to battle the blaze. Assisting Dalton Township were fire departments from the townships of Muskegon, Blue Lake, Holton, Fruitport, and Egelston, along with the North Muskegon and Fremont city departments, the White Lake Fire Authority and Montague Fire District.

Programs and Initiatives

The Scrap Tire Regulatory Program

The Scrap Tire Regulatory Program is implemented by the Waste and Hazardous Materials Division of the Michigan Department of Environmental Quality, under the authority of Part 169 of the Natural Resources and Environmental Protection Act (1994 PA 451), as amended. Policies and regulations established under this law provide the basis for the Department of Environmental Quality to implement and administer an effective scrap tire management program.

Overall, the Program has been very successful. Throughout the state, stockpiles of scrap tires have decreased greatly, compliance rates have increased, and markets for scrap tires have increased. Behind the Program's success to date are: (1) continuing an appropriately funded Scrap Tire Cleanup Grant Program to address abandoned scrap tires and those collected prior to 1991, when a predecessor to Part 169 was enacted, and (2) consistent enforcement of Part 169, which helps to ensure a level playing field for those voluntarily meeting Part 169 requirements. It should be noted that although markets for scrap tire material have continued to increase on their own with minimal governmental subsidies, the ongoing need for state funding for cleanup grants, compliance, and enforcement is clear.

Michigan's policy response to the scrap tire problem in the state is two-pronged: encourage market development and require proper management of scrap tires. The purpose of Part 169 is to help reduce illegal scrap tire accumulations and the public health and environmental concerns associated with these solid waste piles. Under this approach, the MDEQ's goals were to:

- Create regulatory incentives to recycle tires (such as a bonding exemption for sites that are in compliance for one year) and financial disincentives for improperly storing or dumping tires (such as higher bonding requirements and penalties for noncompliance);
- Assist in the development of viable end uses and markets for scrap tires;
- Improve management of scrap tires through registration and manifesting requirements (for transporters) and require proper storage through site registration, pile restrictions, mosquito control, and bonding requirements for storage (based on the number of tires);
- Conduct site, hauler, and retailer inspections to assess their management of scrap tires;
- Conduct appropriate enforcement, with criminal and civil culpability for violations, and prosecution of violations; and
- Allow private enterprise to establish market costs.

Part 169 was substantially amended in July 2002. Amendments were made to the definitions, scrap tire hauler registration exemptions, bonding provisions, manifest requirements, grant provisions, and penalty provisions. The MDEQ did not fully support all of the July 2002 amendments to Part 169 because some were contrary to the goals of the Program and would present great challenges from a regulatory perspective. As a result, Part 169 was again amended, effective December 29, 2006, based on the recommendations of the Scrap Tire Work Group. These amendments were developed in conjunction with, and with the support of the MDEQ. These amendments made substantial improvements to the statute in support of Program goals.

An amendment to reduce regulatory burdens and encourage the productive use of scrap tires by:

- Facilitating the processing of scrap tires into higher-value materials by creating a new category of scrap tires designated as a "commodity." Material that qualifies as a commodity is largely exempted from regulation as a scrap tire.
- Improving the definition of end-user, to clarify who meets the exemption from bonding and storage requirements. Also, clarifying the "scrap tire processor" definition and eliminating the definition of "scrap tire recycler," which has caused confusion for the industry.
- Simplifying the definition of scrap tire hauler, exempting retreaders from hauler registration requirements (as well as persons who haul only recognized commodities).
- Simplifying the manifest requirements by allowing the use of a consolidated load manifest by commercial businesses that service their own truck fleets, and for retail establishments and scrap tire haulers that pick up small numbers of scrap tires from multiple locations in the same load.
- Expanding funding eligibility to allow for research and development, capital expenditures, and other expanded areas under the Scrap Tire Market Development Grant Program.
- Specifying that tires can go to locations that have legally accumulated scrap tires below the regulatory threshold and clarifying whom a person can contract with for the removal of scrap tires.

An amendment to encourage the proper management of scrap tires by:

- Requiring that a collection site be in compliance with storage requirements to qualify for official site registration.
- Improving storage of tires at scrap tire collection sites by specifying that tires may only be stored in areas identified for that purpose on a map provided with the site registration application and approved by the MDEQ.
- Clarifying that shreds cannot be placed between piles. An exception is provided for commodities used to create a storage pad for, or access roads to, other commodities. The use of shredded tires between piles increases the fire danger present at collection sites and makes fighting a fire at a collection site more difficult. The open spaces between the tire piles are there to serve as fire lanes to segregate the tires into piles so that fire would not be as likely to spread between the piles.
- Providing local fire chiefs with the authority to determine whether collection site access roads meet the Part 169 requirement to be accessible at all times to emergency vehicles.
- Limiting the growth of unbonded collection sites. Previously, a scrap tire collection site could grow by 10 percent every year even though it was not bonded, provided that it met certain storage requirements. However, the number of tires should not increase on a properly managed collection site, since scrap tires that are brought in should (after processing, if necessary) leave the site for a market soon thereafter.
- Facilitating the proper use of portable shredding operations to clean up scrap tire piles, by ensuring that there is a tie to a properly registered collection site.

An amendment to support the public interest by:

- Providing the state with limited lien authority when state funds are used to clean up tire piles that were created illegally after the predecessor to Part 169 was enacted in 1991. This prevents the unjust enrichment of property owners from the public funds used to eliminate a problem that the landowner had created and profited from.
- Adding explicit inspection authority that allows the MDEQ to conduct inspections at reasonable times to enforce and administer Part 169.

An amendment to provide for the long-term success of the Program by:

- Extending the sunset on Program funding from 2007 to 2012. The Program is funded through a fee of $1.50 for each motor vehicle title transfer, established in the Motor Vehicle Code, 1949 PA 300, as amended (MVC). Continued Program funding was needed to allow the MDEQ to meet the 2009 statutory deadline for clean-up of pre-1991 scrap tires, and to continue efforts to clean up those post-1991 scrap tires that pose a danger to public health, safety, welfare, or the environment. Continued funding also

supports ongoing grants to develop markets for scrap tires and helps to ensure proper disposal of the 10 million scrap tires generated annually in Michigan.

- Adding a requirement for the MDEQ to report every three years on the effectiveness of Part 169 in encouraging reuse and ensuring safe storage of scrap tires. (To read the full 2009 Report, please go to http://www.michigan.gov/documents/deq/DEQ-WHMD-STPTri_Scrap_Tire_Leg_Rpt_2009_309005_7.pdf .)
- Adding a requirement for the MDEQ Director to appoint the Scrap Tire Advisory Committee to advise the MDEQ on the required report, the relevance of national standards and specifications for commodities, and other issues.

Scrap Tire Management

To be effective, scrap tire management must be viewed from two perspectives. First, methods for dealing with the millions of scrap tires currently being generated must be devised to stop the problem from growing in scope and magnitude. Recycling and re-use appear to be the best options in that regard. Second, measures must be devised to address the issues pertaining to the millions of scrap tires already present in existing disposal sites.

Mitigation of Scrap Tire Fires

To combat these problems at current disposal sites, suggestions have been made about establishing a state policy and program for acquiring such sites and suitably disposing of the tires at these locations. Other proposals call for educating local jurisdictions on the hazards associated with scrap tire disposal sites so that enforcement of existing legislation is effective in minimizing future potential scrap tire fires.

The EPA developed the Resource Conservation Challenge (RCC), which is a national effort to find more flexible, yet effective ways to conserve natural resources and energy. In 2004, the RCC developed a program to clean up scrap tire piles in the Great Lakes Region. The project supports prioritization, funding and implementation of clean up efforts. The goal was to clean up 55% of tires in stockpiles (from the "2001 baseline") in the Great Lakes region, by 2008. The mitigation of these sites will provide for land revitalization and elimination of a potential source of benzo[a]pyrene (a PBT) in the Great Lakes, which are priorities of the Brownfields Program and Bi-National Toxics Strategy, respectively. A map showing the locations of regulated outdoor scrap tire piles in Michigan can be seen on the MDEQ web site at
http://www.michigan.gov/documents/deq/deq-whm-stsw-scraptiresites_230376_7.pdf.

The November 2006 RMA Scrap Tire Market Report ranked Michigan as tied with Ohio for being the third most improved state in the number of tires consumed by markets reduction of historical stockpiles, on absolute and per capita bases. According to the May 2009 RMA Scrap Tire Market Report, there were about 128 million scrap tires remaining in stockpiles throughout the United States at the end of 2007. This is a reduction of about 87% percent since 1990, when the number of tires in stockpiles was estimated at 1 billion. The reduction of tires below the 2001 baseline level (of 308.4 million) also marks a 58% reduction in stockpiles and therefore exceeds the EPA stakeholders' 2004 goal (of 55%), an accomplishment of which the industry should be proud.

Much of the reduction in illegal stockpiles in Michigan is due to Scrap Tire Cleanup Grants. Since the Legislature first appropriated funding in 1993, more than $27.2 million in public funds have cleaned up approximately 31.1 million Passenger Tire Equivalents (PTEs), restoring the environmental quality and economic value of more than 1,000 sites across the state. The average cost of removal of tires under the grant program has been 88 cents per PTE. Approximately $2.5 million is allocated for cleanup grants in fiscal year 2010. Based on the eligible applications received to date, it is estimated that at least another 1 million PTEs will be removed during the FY 2010 grant cycle.

Scrap Tire Fire Statewide Response Plan

To comply with the 2002 amendments to Section 169 of the Natural Resources and Environmental Protection Act, the State of Michigan has developed a statewide response plan for large scrap tire fires. This plan, which was written by the Michigan Department of Environmental Quality with input from the Michigan State Police and the

Michigan Association of Fire Chiefs, establishes a framework for planning, preparedness and response measures for large scrap tire fires. While this plan will not entirely stop scrap tire fires from occurring, it is hoped that the plan will at least keep the problem in check until more permanent hazard mitigation measures can be instituted to reduce the threat of tire fires across Michigan.

Scrap Tire News

Scrap Tire News is a publication devoted to providing news and information about tire and rubber recycling. In addition to in-depth tire recycling company profiles that explore operational and market issues facing the industry, Scrap Tire News also provides a way to stay current with changes in the industry through regular reports on technology/design developments and breakthroughs; timely legislative and regulatory information; market trends; product briefs; product advances; global viewpoints; internet guides; and updates on equipment innovations and applications occurring throughout the industry.

The Recycling Research Institute, Suffield, CT (RRI) develops and disseminates information concerning the recovery, reuse, recycling and proper disposal of scrap tires and scrap rubber. In addition to publishing Scrap Tire News, the company produces and publishes the Scrap Tire & Rubber Users Directory—a nationally acclaimed business reference book for the scrap tire and rubber recycling industry. Another RRI publication, State Scrap Tire Management Programs, covers comprehensive profiles of state scrap tire legislation, regulation, and market development initiatives in all 50 states.

Scrap Tire Cleanup Guidebook

The Scrap Tire Cleanup Guidebook was created to help state and local and local governments reduce the economic burdens and environmental risks associated with scrap tire piles on their lands. The U.S. EPA Region 5 and Illinois EPA, along with the Michigan Department of Environmental Quality, have collaborated to create the Scrap Tire Cleanup Guidebook. The guidebook brings together the experience of dozens of professionals into one resource designed to provide state and local officials with the information needed to effectively clean up scrap tire piles. The guidebook discusses starting a cleanup program, working with contractors to clean up sites, and implementing prevention programs that will reduce scrap tire dumping.

The scrap tire clean up guidebook has a section on fire planning and prevention for site stabilization. Removal of trees, brush, and grass around stockpiles is an effective mitigation measure to avoid fire transmission to and from surrounding areas, especially if the site is inactive. Identification of available fire control resources, installation of supplemental fire control tools, the provision of at least two connected access points for emergency vehicles, and fire lanes (at least 50 feet wide) to divide a large stockpile into isolated segments, can all help to mitigate scrap tire fires. The pile sides should also be tapered to avoid collapse during fire turbulence. Piles generally should be removed early in the abatement process to prevent tire ignition by thrown objects as well as to show abatement progress.

Scrap Tire Advisory Committee (STAC)

The STAC was originally created by the Waste and Hazardous Materials Division in September 2005 to foster continued interaction between the MDEQ and other stakeholders. The STAC grew out of the Scrap Tire Work Group which was formed in April 2005 to assist the MDEQ with developing recommendations for statutory amendments and other regulatory and policy changes to improve the Scrap Tire Program administered under Part 169 of the Natural Resources and Environmental Protection Act. The Scrap Tire Work Group process highlighted the benefits of having a forum for the MDEQ and stakeholders to exchange information. The STAC will be available to advise the MDEQ on the implementation of Part 169 and to allow both the MDEQ and other stakeholders to identify and address challenges and opportunities in the Scrap Tire Program as they arise. In addition to any other issues the MDEQ wants the STAC to consider, the STAC shall advise the MDEQ on the report required every three years concerning the effectiveness of Part 169 and the relevance of national standards and specifications for commodity determinations.

Michigan Manufacturers' Guide to Environmental, Health, and Safety Regulations

The 2008 "Michigan Manufacturers' Guide to Environmental, Health, and Safety Regulations" is a joint publication of Michigan's Department of Natural Resources, the Department of Environmental Quality and the Department of Licensing and Regulatory Affairs. Manufacturers, suppliers, consultants, and regulators can all benefit from this guide, which steers the reader through the maze of state and federal environmental, health, and safety regulatory programs. Section 2.2.2 (2-7) of the environmental regulations is a section that deals specifically with scrap tires and includes basic requirements for scrap tire generators.

Michigan Department of Environmental Quality, Common Scrap Tire Violations Index

The Michigan Department of Environmental Quality website has an index that is organized into categories of registration application deficiencies and violations common to scrap tire collection sites and scrap tire haulers (http://www.michigan.gov/deq/0,1607,7-135-3312_4122-60866--,00.html). The violations or deficiencies have been identified either during scrap tire collection site or scrap tire hauler inspections, or upon review of registration applications, by MDEQ Waste and Hazardous Materials Division (WHMD) staff. It is not a comprehensive list of all requirements that staff look for while doing inspections or reviews, but should be helpful for those involved with tire storage/disposal sites.

Hazard Mitigation Alternatives for Scrap Tire Fires

- Policies for regulated disposal and management of scrap tires, and enforcement of regulations related to them (separation of stored scrap tires from other materials; limits on the size of each pile; minimum distances between piles and property lines; covering, chemically treating, or shredding tires to limit mosquito breeding; providing for fire vehicle access to scrap tire piles; training employees in emergency response operations; installation of earthen berms around storage areas; prevention of pools of standing water in the area; control of nearby vegetation; an emergency plan posted on the property; storing only the permitted volume of tires authorized for that site).
- Proper siting of tire storage and processing facilities (land use planning that recognizes scrap tire sites as a real hazard and environmental threat).
- Pest-control measures for mosquitoes and other nuisances around scrap tire yards.

Tie-in with Local Hazard Mitigation Planning

Because many means of implementing mitigation actions occur through local activities, this updated MHMP places additional emphasis on the coordination of State-level planning and initiatives with those taking place at the local level. This takes two forms:

1. The provision of guidance, encouragement, and incentives to local governments by the State, to promote local plan development, and
2. The consideration of information contained in local hazard mitigation plans when developing State plans and mitigation priorities.

Regarding the first type of State-local planning coordination, MSP guidance has included the "Local Hazard Mitigation Planning Workbook" (EMD-PUB 207), which is currently being updated for release by 2015. For the second type of State-local planning coordination, a section later in this plan summarizes hazard priority information as it has been reported in local hazard mitigation plans. Here, it will merely be noted that the scrap tire fire hazard is not currently identified as one of the most significant hazards in any of Michigan's county hazard mitigation plans. It had previously been identified within the hazard analysis for Osceola County, but since then the number of scrap tires has been shrinking, and the hazard is likely considered to be less significant now.

HAZARDOUS MATERIAL INCIDENTS

A hazardous material is any solid, liquid, or gas that can cause harm to humans and other living organisms due to its being radioactive, flammable, explosive, toxic, corrosive, a biohazard, an oxidizer, an asphyxiant, or capable of causing severe allergic reactions. Mitigating the risks associated with hazardous materials often requires extensive safety precautions during their transport, use, disposal and storage. Hazardous materials are transported by highway, rail, pipeline, air, and water.

Impact on the Public

Both fixed site and transport-related hazardous material incidents involve the potential for evacuation (or sheltering in place), with significant problems possible for special populations in hospitals, schools, nursing homes, and other critical facilities. Certain types of extremely hazardous substances may result in a public health emergency, and a resulting need for triage, mass treatment, and congregate care. In addition to the direct impacts of the hazardous material event itself, transportation incidents may directly affect the transportation infrastructure in the area and cause extensive delays in travel and the conduct of business. This hazard is ranked as the second most frequent in occurrence (behind structural fires).

Impact on Public Confidence in State Governance

Discontent may arise from the NIMBY problem (as referred to in the Scrap Tire Fires section) or from difficulties in planning to avoid conflicting land uses. Mixed attitudes toward useful and needed employers/businesses may be fairly common, recognizing the economic benefits of companies that use hazardous materials, but unsettled by the perceived risks in the location of some of them (or their number, since there were 2,991 SARA Title III sites in Michigan in late 2009). Such perceptions of risk may be over-generalized toward other, undeserving businesses (e.g. those that pose minimal risks). Part of the public may not understand the balance between regulation and business needs concerning the use and handling of hazardous materials. Transportation delays due to transportation-related incidents may cause dissatisfaction with roadway provision, capacity, and maintenance.

Impact on Responders

Special procedures and additional information tend to be needed for incidents involving hazardous materials. Additional risks to responders may be present from exposure to extremely hazardous substances at or near these incident locations. Exposure can involve direct contact, the presence of toxic fumes, or the risk of fires and explosions from chemical reactions. Additional complexity therefore tends to be present in any response involving hazardous materials. A schedule of exercise activities needs to be maintained for staff preparedness, and larger budgets are needed to accommodate the staffing, training, exercising, and equipment needed. In addition to preparing for and handling this type of response, the creation, support, and participation in a Local Emergency Planning Committee is needed, along with work related to Section 302 site planning and mutual aid arrangements with nearby communities and relevant agencies. Extra work is also involved in creating and maintaining special contact lists for railroads, the MDEQ, drain and road commissions, airports, health departments, and private companies who may also be involved in incident response, as well as the State Emergency Operations Center (SEOC) and its notification/coordination procedures and protocols. Special expertise in substance types and risks, as well as software for plume modeling may also be needed for effective response, and such expertise has an expense associated with its development and maintenance.

Impact on the Environment

An incident involving hazardous material, whether at a fixed site or during transportation, may cause harm to the environment, as various types and quantities of chemicals are released. A hazardous spill involving an industrial or chemical plant can affect air quality, soil surrounding the area of the release, and an area's drinking water. A hazardous spill caused by a transportation accident can similarly impact the air, soil, and nearby lakes and rivers. A toxic release can also destroy the wildlife habitat in or around the areas where the release occurs.

HAZARDOUS MATERIAL INCIDENTS: FIXED SITE
(INCLUDING INDUSTRIAL ACCIDENTS)

Hazardous Material Incident – Fixed Site: An uncontrolled release of hazardous materials from a fixed site capable of posing a risk to life, health, safety, property or the environment.

Industrial Accident: A fire, explosion, or other severe accident (especially if it involves hazardous materials) at an industrial facility that results in serious property damage, injury, or loss of life.

Hazard Description

Hazardous Material Incidents

Over the past few decades, new technologies have developed at a stunning pace. As a result, hazardous materials are present in quantities of concern in business and industry, agriculture, universities, hospitals, utilities, and other facilities in our communities. Hazardous materials are materials or substances which, because of their chemical, physical, or biological nature, pose a potential risk to life, health, property, or the environment if they are released. Examples of hazardous materials include corrosives, explosives, flammable materials, radioactive materials, poisons, oxidizers, and dangerous gases.

Hazardous materials are highly regulated by federal and state agencies to reduce risk to the general public and the environment. Despite precautions taken to ensure careful handling during the manufacture, transport, storage, use, and disposal of these materials, accidental releases do occur. These releases can cause severe harm to people or the environment, and response actions often need to be immediately performed. Most releases are the result of human error. Occasionally, releases can be attributed to natural causes, such as a flood that washes away barrels of chemicals stored at a site. However, those situations are the exception rather than the rule.

Industrial Accidents

Industrial accidents differ from hazardous material incidents in the scope and magnitude of offsite impacts. Whereas hazardous material incidents typically involve an uncontrolled release of material into the surrounding community and environment that may require evacuations or in-place sheltering of the affected population, the impacts from industrial accidents are often confined to the site or facility itself, with minimal physical outside impacts. Nonetheless, industrial accidents, such as fires, explosions, and excessive exposure to hazardous materials, may cause injury or loss of life to workers at the facility, and significant property damage. In addition, industrial accidents can cause severe economic disruption to the facility and surrounding community, as well as significant long-term impacts on the families of the workers injured or killed.

Hazard Analysis

Hazardous Material Incidents

The map at the end of this section illustrates where the identified SARA Title III facilities are located in Michigan. An examination of the map indicates that the greatest concentration of facilities is located in southeastern Michigan and other urbanized areas. Fortunately, these are generally the areas with more resources to prepare for and respond to a hazardous material incident. However, the greater population concentrations also make these areas more vulnerable to a serious hazardous material incident.

Like all heavily industrialized states, Michigan will always be concerned with the risk of accidental hazardous material releases. However, the threat of accidental hazardous material releases that can affect life, health, property or the environment can be greatly reduced by: 1) developing and maintaining adequate community hazardous material response plans and procedures; 2) adequately training hazardous material workers and off-site emergency responders; 3) educating the public about hazardous materials safety; 4) enforcing basic hazardous material safety regulations; and 5) mitigating, wherever possible, the threat of accidental hazardous material releases. Fortunately, many Michigan communities are making great strides in these important areas.

NOTE: Nuclear research facilities can produce / use radioactive materials, as well as other hazardous substances, and therefore need to be dealt with by specially trained personnel. Caution should be exercised at these facilities, and proper radiological survey equipment should be used during a response.

Industrial Accidents

As a major manufacturing and industrial center, Michigan has had its share of industrial explosions and/or fires that resulted in deaths or injuries. Fortunately, industrial and fire safety regulations enacted over the years have kept these types of accidents to a minimum. Although industrial accidents occur with regularity in Michigan, major incidents with mass casualties, such as the four deadly explosions that occurred in 1998 and 1999, are relatively rare.

Significant Fixed-Site Hazardous Material Incidents and Industrial Accidents

December 3, 1984 – Bhopal, India

The world's worst hazardous material incident occurred on December 3, 1984 in Bhopal, India when a cloud of methyl isocyanate gas (an extremely irritating chemical that can cause severe acute respiratory problems) escaped from a Union Carbide chemical plant, killing about 2,500 persons and injuring tens of thousands more. Many of the injured later suffered permanent disabilities. Over 30 tons of the chemical was released. The exact cause of the release was not firmly established, but several safety systems designed to prevent a major release were either inoperative, under maintenance, or not activated by workers. Atmospheric conditions at the time of the release kept the toxic cloud close to the ground as it slowly drifted over the city, increasing the number of persons exposed. Unfortunately, warning systems for the community were not activated in a timely manner and many individuals died in their sleep.

The Bhopal incident helped to illustrate many important points about accidents that involve a release of hazardous materials. First, it was not caused by a single factor; rather, a number of contributing events had to occur for the methyl isocyanate to be released and have such a deadly public health impact. Second, human error and lack of adherence to safety rules and procedures played a substantial role in the incident. Third, the impact would not have been nearly so great had the population around the plant not been so large and densely housed, and had there been better preparation about how to respond to a hazardous materials release. Finally, the deadly release proved that worst-case scenarios do occur, and that emergency planning, training, and education must be geared toward that worst-case incident.

As tragic as the Bhopal incident was for India, it did have a positive side in that it triggered historic federal legislation intended to prevent such disasters from occurring in the United States. Shortly after the Bhopal incident, Congress enacted legislation (the Superfund Amendments and Reauthorization Act, signed into law October 17, 1986) that established new requirements for federal, state and local government, and private industry, for reporting on and planning for hazardous material incidents. (See the Programs and Initiatives section for more information on this law.)

NOTE: A reportable hazardous material incident is one in which all three of the following conditions apply: (1) a material is present that is suspected to be other than ordinary, combustible by-product material; (2) the material is in such a state, quantity or circumstance that, if left unattended, it is presumed to pose a threat to life, health, property or the environment; and (3) special hazardous material resources were dispatched or used, or should have been dispatched or used, for assessing, mitigating or managing the situation.

May 25, 1865 – Mobile, Alabama

On May 25, 1865, in Mobile, Alabama, an ordnance depot exploded, resulting in about 300 fatalities. This event occurred just after the end of the American Civil War. The depot was a warehouse where troops had stacked about 200 tons of shells and powder. The shells caught fire and exploded, with flames shooting up into the sky and bursting shells heard throughout the city. After the explosion, there were fires that burned until the entire northern part of Mobile was destroyed. The exact cause of the explosion was never determined.

December 6, 1917 – Halifax, Nova Scotia, Canada

One of the biggest and most deadly explosions occurred on December 6, 1917 in Halifax, Nova Scotia, Canada. It is known as the Halifax Explosion. The incident occurred when a French freighter carrying ammunition and wartime explosives collided with a Norwegian ship in Halifax Harbor. About 2,000 people were killed by debris, fires, or collapsed buildings, and it is estimated that over 9,000 people were injured. The French ship had caught on fire 10 minutes after the collision and exploded about 25 minutes later. The explosion was equivalent to about three kilotons of TNT and a fireball rose over a mile in the air to form a giant mushroom cloud. All of the buildings and structures covering nearly 2 square kilometers along the adjacent shore were destroyed, including those in the neighboring communities of Richmond and Dartmouth. The explosion also caused a tsunami in the harbor, with waves as high as 60 feet and a pressure wave of air that snapped trees, bent iron rails, demolished buildings, grounded vessels, and carried fragments of the ship for miles.

March 18, 1937 – New London, Texas

On March 18, 1937 the deadliest school disaster in United States history occurred in New London, Texas. An explosion was caused by a natural gas leak and resulted in the death of at least 295 students and teachers. Approximately 600 students and 40 teachers were in the building at the time, and only about 130 escaped without serious injury.

July 17, 1944 – Port Chicago, California

A major munitions explosion occurred at a naval base in Port Chicago, CA on July 17, 1944. The incident occurred during World War II, when munitions detonated while being loaded onto a cargo vessel, killing 320 sailors and civilians and injuring 390 others. The explosion resulted in an enormous fireball.

October 20, 1944 – Cleveland, Ohio

A significant gas explosion occurred on October 20, 1944 in Cleveland, Ohio. It resulted in 130 fatalities and destroyed one square mile around Cleveland's east side. The event occurred when an above-ground storage tank, holding liquefied natural gas in the East Ohio Gas Company's tank farm, began to emit vapors. As the gas flowed and mixed with air and sewer gas, the mixture ignited. In the ensuing explosion, manhole covers launched skyward and massive

fires erupted from the depths of the sewer lines. Then a second above-ground tank exploded, leveling the tank farm. The explosions and fires continued to occur, trapping many who had returned to what they thought was the safety of their own homes. Over 600 people were left homeless, and 70 homes, two factories, many cars and miles of underground infrastructure were destroyed. The explosion also had a long-range impact on the natural gas industry. Until the disaster, above-ground storage of natural gas, used as fuel for homes, office buildings and factories, was a common sight in cities across America. Following the disaster, utility companies and communities began to rethink their natural gas storage systems, and below-ground storage of natural gas grew in popularity.

April 16, 1947 – Texas City, Texas

One of the worst industrial accidents in United States history occurred on April 16, 1947 in Texas City, Texas. Approximately 2,300 tons of ammonium nitrate detonated and resulted in a chain reaction of fires and explosions. The incident started with a mid-morning fire on board the French-registered vessel SS Grandcamp in the port of Texas City. The fire led to a massive explosion that sent a 15 foot wave across the water—a wave that was detectable along about 100 miles of the Texas shoreline. The incident resulted in at least 581 fatalities, over 5,000 injuries, and the destruction of nearly 1,000 buildings, including a Monsanto Chemical Company plant. The Grandcamp explosion also caused the ignition of refineries and chemical tanks on the waterfront. Windows were shattered 40 miles away in Houston, and people reported feeling the shock about 250 miles away.

The Texas City disaster triggered the first ever class action lawsuit against the United States government, under the then-recently enacted Federal Tort Claims Act (FTCA), on behalf of 8,485 victims. The Texas City disaster led to widespread disaster response planning to help organize local and regional responses to emergencies. Offers of assistance came in from all over the country and several funds were established to handle donations, mainly the Texas City Relief Fund.

Hazardous Material Incidents

Michigan has not experienced such a large-scale hazardous material release involving mass casualties as that which occurred in Bhopal, India. This can be attributed, in large part, to the steps taken by government and private industry to carefully regulate those processes and practices that could cause an accidental hazardous material release. Michigan's population density is also lower, and its zoning and planning personnel tend to separate conflicting land uses from each other. Bhopal's 2001 population density was 12,655 persons per square mile, whereas Michigan's highest population density (according to the 2010 census) is the city of Hamtramck, at 10,751 persons per square mile. (Hamtramck, coincidentally, had a hazardous materials event of its own in 1984, as described later in this section.) Bhopal's population was reported as totaling 1.5 million in 2001—Michigan's smaller and more widely spaced urban developments tend to make it less vulnerable to the most severe types of impacts, as do the regulations it currently has in place to oversee the handling of extremely hazardous substances.

However, as the list on the following pages illustrates, Michigan has had numerous fixed-site hazardous material incidents in recent years that required a response by local fire departments and hazardous material response teams, and implementation of evacuation, in-place sheltering, and other protective actions. From 1994 through 1998, local fire chiefs in Michigan reported 730 hazardous material incidents on the Michigan Fire Incident Reporting System (MFIRS). Of those 730 reported incidents, approximately 15-20% (about 120 incidents) occurred at an industrial or service business site. That figure represents an average of one reportable fixed-site hazardous material incident statewide approximately every 15.2 days. (Note: 1998 is the last year for which statewide hazardous material incident response statistics were available.)

Industrial Accidents

Michigan has seen its share of tragic industrial accidents over the past few years, resulting in numerous deaths and injuries, serious property damage, and economic disruption to facilities and their surrounding communities. Following are brief synopses of the more significant accidents and their impacts:

Some Significant Industrial Accidents in Michigan

March 21, 1892 – East Jordan (Charlevoix Co.) – Explosion at Lumber Mill

On March 21, 1892 a boiler explosion occurred at a lumber mill in East Jordan. The accident resulted in six fatalities and three others left critically injured. The noise from the explosion could be heard from 14 miles away.

November 6, 1895 – Detroit (Wayne County) – Boiler Explosion at a Building

Another major fatal accident occurred on November 6, 1895 when a boiler explosion occurred in Detroit. The boiler exploded in the basement of the building occupied by the Detroit Journal and destroyed the building as well as another adjacent building. The incident resulted in at least 40 fatalities, and 20 more injuries. Several buildings on nearby blocks were shaken by the force of the explosion.

April 23, 1927 – Detroit (Wayne County) – Explosion/Fire at Automobile Plant

One of Michigan's worst industrial accidents occurred in Detroit on April 23, 1927 at the Briggs Manufacturing Plant (which built and painted auto bodies and parts for several automobile companies). In that accident, 21 workers died when sparks from machinery or mercury-vapor lamps in the paint booths ignited paint fumes, causing an explosion and tremendous fire that killed the workers and severely damaged the plant. Arson investigators later determined the explosion and fire to be accidental.

October 2, 1961– Detroit (Wayne County) – Explosion at Plastics Plant

On October 2, 1961 four people were killed and two others injured in an explosion in Detroit. The incident occurred at a plastics plant and the explosion occurred in a large gas-operated steam heating boiler.

December 11, 1971 – Port Huron (St. Clair County) – Explosion at Water Treatment Plant

A significant construction operation accident occurred on December 11, 1971 in Port Huron when 22 workers perished in a water project tunneling incident. The explosion occurred within a six-mile, 16-foot diameter tunnel that was being constructed 230 feet below the lake bed to draw up to 1.2 billion gallons of water per day when complete. Tragically, methane gas accumulated in an unventilated portion of the tunnel and was later inadvertently sparked, leading to the devastating underground explosion. Forty-three men were in the tunnel when it exploded. Twenty-one men were killed that day and another man got out of the tunnel but died 10 months later. The explosion ranks as one of the state's most deadly construction industrial accidents.

January 23, 1976 – Zilwaukee (Saginaw County) – Explosion at Grain Elevator

On January 23, 1976 five workers were killed and 12 others were injured in a grain elevator explosion in Zilwaukee, MI. The explosion occurred in a tower seven stories tall that housed grain hoists and other equipment. Eighteen men were working in the area at the time. The explosion was so powerful that it showered chunks of concrete over an acre of ground.

December 11, 1998 – Osseo (Hillsdale County) – Fireworks Plant Explosion

On December 11, 1998 an explosion at the Independence Professional Fireworks Company manufacturing plant near Osseo, in Hillsdale County, killed seven employees and leveled one building at the site. The blast, which occurred in a fireworks shell assembly room, sent debris flying in all directions for about 300 yards and could be heard for at least 20 miles. Fifteen other workers escaped serious injury in the explosion. Subsequent investigations by the Federal Bureau of Alcohol, Tobacco and Firearms, the Michigan State Police Fire Marshal Division, and the Michigan Occupational Safety and Health Administration (MIOSHA) were unable to determine a definitive cause of the explosion. This explosion was the worst industrial accident in Michigan in 20 years.

February 1, 1999 – Dearborn (Wayne County) – Automobile Plant Boiler Explosion

On February 1, 1999 an explosion in one of several large boilers at the Ford Motor Company Rouge Power Plant killed six workers, critically injured another 14, and caused extensive structural damage. State officials who investigated the accident concluded that human error played a major part in the explosion, when a work crew failed to shut off one of two gas mains leading to the boiler's furnace. That error caused a buildup of natural gas in the boiler that was somehow ignited and caused the explosion. The force of the explosion split open the 60-foot high furnace, blew off the roof of the power plant, ignited fires on five floors, and sprayed surrounding workers with super-heated water that caused severe burns. The blast, which forced the shutdown of the Rouge Complex and other Ford plants for several days, was the second worst industrial accident in Michigan in 20 years and the deadliest at an automobile plant in over 50 years. It also turned out to be the most expensive workplace disaster in U.S. history, with final costs of at least $1 billion. The seven-month probe by state officials was the largest and most complex in the history of state workplace safety investigations.

March 29, 1999 – Osseo (Hillsdale County) – Fireworks Plant Explosion

Another devastating explosion occurred at the same plant that had suffered a disastrous explosion the previous year, killing five more employees and destroying another building at the site. This second explosion, which included among its victims the company co-owner, was later determined by investigators to be accidental. The devastation brought by the two explosions, which resulted in a total of 12 deaths, forced the company to permanently shut down the business. Federal and state regulators have since issued numerous citations to the company for safety violations at the plant, with fines totaling several hundred thousand dollars.

November 10, 1999 – Flint (Genesee County) – Nursing Home Explosion

On November 10, 1999 an explosion at the Clara Barton Terrace Convalescent Home in Flint killed five persons, injured 32 others, and caused extensive to the basement and other parts of the facility. Although several theories surfaced as to the cause of the blast, subsequent investigations by the National Transportation Safety Board (NTSB) and the Michigan Department of Consumer and Industry Services (as it was then called) had stalled. The NTSB withdrew from the investigation in January 2000 after its investigators could find no pre-existing conditions linking the blast to natural gas lines leading to the nursing home. The Michigan Department of Consumer and Industry Services also pulled out of the investigation after determining that three boilers in the facility's basement were intact and not likely to be the cause of the blast. Officials had indicated that determining the cause of the explosion may be difficult unless new information comes to light.

April 12, 2000 – Muskegon (Muskegon County) – Chemical Plant Explosion

On April 12, 2000 two explosions occurred in rapid succession at a chemical plant in Muskegon, resulting in 10 workers sustained injuries. The contract workers were installing two tanks and upgrading the waste treatment system at the site of the explosions. The first, smaller blast occurred in a two-inch stainless steel pipe leading from a building to the wet well. The second, larger blast occurred below grade in the southwest quadrant of the wet well. The facilities sustained substantial damage from the second blast and the estimated magnitude of the second blast was equivalent to 250 pounds of TNT.

March 18, 2001 – Warren (Macomb County) – Plant Explosion

A plastics coating plant building was completely destroyed by a natural gas explosion around 8:20 am on a Sunday morning. Fortunately, no one was at the plant to be injured or killed by the explosion, but the 75 workers employed by the plant no longer had a place to come to work at, on Monday morning.

May 25, 2001 – Bagley Twp. (Otsego County) – Particle Board Plant Explosion

Two separate explosions on May 25 and 26, 2001, at a mill near Gaylord that produces particle board, injured a total of seven firefighters and nine plant workers (five critically), and caused extensive structural damage to the building. The first explosion occurred on May 25 in an area where glue is mixed with wood chips. The second explosion occurred on May 26 when the initial fire spread to an adjacent silo containing wood chips. As firefighters opened the silo to spray water on the flames, the sudden infusion of oxygen caused the blast.

July 21, 2002 – Battle Creek (Calhoun County) – Auto Supplier Factory Explosion

An explosion and a fire at a Johnson Controls Inc. plant sent seven employees and three firefighters to the hospital. The victims were not badly hurt and were quickly treated and released. They all suffered headaches and eye and skin irritation caused by the burning of an unknown toxic substance. The fire was extinguished in about 25 minutes and the plant suffered minor damages. Fire crews remained on the scene to clean up the hazardous materials.

September 17, 2003 – Dearborn (Wayne County) – Explosion at Industrial Plant

A leaking oxygen line exploded outside the Rouge Steel plant in Dearborn and destroyed 20 employee cars in the area. Five hundred employees were evacuated from the plant. The fire department later ordered a second round of evacuations, as a precautionary measure. No injuries were reported in the incident.

March 21, 2005 – Dearborn (Wayne County) – Explosion / Fire at Industrial Plant

Spilled molten steel caused a fire and two explosions on March 21, 2005 at a Dearborn steel plant, injuring 10 people. A vehicle carrying molten steel was backing into a building at the sprawling River Rouge industrial complex when some of its high-temperature cargo sloshed out, causing the fire and explosion.

August 9, 2005 – Romulus (Wayne County) – Chemical Plant Explosion

A series of explosions and fires occurred at a chemical plant in Romulus on August 9, 2005. Potentially toxic soot was strewn across neighborhoods surrounding the plant, and dangerous chemicals stewed in the hot rubble left by the explosions. The event caused evacuations within the cities of Romulus and Wayne and caused an environmental health scare. It was later determined that the debris strewn from the plant was not toxic, and the fire was put out after two days of burning.

February 20, 2006 – Hamtramck (Wayne County) – Explosion / Fire at Industrial Plant

Three people were injured after an explosion at an industrial plant in Hamtramck. The explosion occurred at a hydraulic pump station. The Hamtramck Fire Department and Detroit Fire Department responded to the explosion and were able to control the flames.

August 28, 2006 – Detroit (Wayne County) – Explosion / Fire at Chemical Plant

Several explosions and a fire spread through a chemical facility on Detroit's east side. The fire started in an aerosol decommissioning area. Three employees suffered injuries, and residents within a half-mile of the plant had to be evacuated for several hours.

April 4, 2007 – Chesterfield (Macomb Co) – Explosion / Fire at Plastics Plant

A fire at a plastics plant resulted in an explosion involving at least 30 propane tanks. The explosion knocked down phone lines, disabling the Chesterfield Township 9-1-1 system. Police shut down 21 Mile Road near Interstate 94, as firefighters struggled with high winds, terrain obstacles, and nearby power lines. There were no injuries.

August 4, 2009 – Clio (Genesee County) – Explosion / Fire at Chemical Plant

Explosions and a fire occurred at a chemical plant in Genesee County, resulting in more than 100 firefighters battling the blaze at the facility. An evacuation was ordered for a 2-mile wide radius around the fire, displacing roughly 1,000 residents. The Environmental Protection Agency advised those in the area to keep their windows closed.

August 27, 2009 – Hamtramck (Wayne County) – Explosion / Fire at Chemical Plant

A fire and an explosion at a chemical plant forced the temporary evacuation of hundreds of people and sent huge plumes of black smoke billowing into the sky above Detroit. The fire began when a rail tanker car ignited while being refueled. Drivers were told to evacuate the service drive in that area in both directions. About 300 homes in the Hamtramck Colonel housing development adjacent to the plant were also evacuated. Amtrak passenger rail service was suspended between Pontiac and Detroit. Amtrak passengers were shuttled about 20 miles between the cities by charter bus. There were no reports of injuries.

October 20, 2009 – River Rouge (Wayne County) – Explosion / Fire at Industrial Plant

Billows of thick, black smoke could be seen for miles on October 20, 2009 after a fire engulfed an asphalt spill nearly the size of a football field in an industrial area southwest of Detroit. The blaze at the plant was largely contained to its outdoor storage yard. A roughly 100-gallon oil tank also exploded during the fire. Hazardous materials crews, environmental cleanup workers, and other emergency personnel responded to the scene.

August 24, 2009 – Detroit (Wayne County) – Explosion / Fire at Industrial Plant

A fire at a Detroit chemical company was caused by chemicals inside a heating oven that caused several explosions and the factory to be evacuated. The fire created thick black smoke and could be seen in the air for miles. One firefighter was taken to a hospital with minor injuries.

November 2, 2009 – Marysville (St. Clair County) – Explosion / Fire at Chemical Plant

Fire crews extinguished a blaze with thick plumes of black smoke at a welding supply company in Marysville after a series of explosions rattled the nearby neighborhood, injured a worker, and sent pieces of metal flying through the air. About 15 to 20 nearby residents, Cleveland Elementary School and the Grant Education Center, along with some nearby businesses, were ordered to evacuate the area. Authorities told others to stay inside and close the windows because of the potential for airborne chemicals. Hazmat teams surveyed the area for several hours after the blast and determined that the air quality around the fire did not endanger the residents. Everyone was allowed to return to their homes.

Selected Fixed-Site Hazardous Material Incidents in Michigan Since 1976

January 22, 1976 – Saginaw (Saginaw County)

An explosion and fire at a farm supply shipping plant and grain tower killed five persons and injured 12 others. Grain storage areas often contain air that becomes loaded with flammable dust and has a high risk of an explosion being triggered from a spark or flame.

October 7, 1977 – Midland (Midland County)

A chlorine gas leak valve burst on a tank at chemical plant, producing a vapor cloud that incapacitated several schools. A total of 1,500 students and another 5,000 residents were evacuated.

May 3, 1979 – Adrian (Lenawee County)

Curene 442 (a chlorinated hydrocarbon) leaked from a plant into the nearby sewers in a five block area, affecting the Raisin River.

April 23, 1981 – Swartz Creek (Genesee County)

A court-ordered hazardous waste site cleanup forced the evacuation of 60 residents for one month. The possibility of cyanide and acid mixing had prompted the evacuation.

April 28, 1983 – Benton Harbor (Berrien County)

A chemical spill at a manufacturing plant (involving 6,500 gallons of toluene di-isocyanate) forced the closure of M-139.

June 17, 1983 – Shelby Twp. (Macomb County)

A fire at a hazardous waste site caused six injuries and forced the evacuation of 1,200 people.

March 5, 1984 – Adrian (Lenawee County)

A fire at a plastics plant (involving polystyrene) forced the evacuation of 1,000 people from nearby mobile home parks and a subdivision.

August 6, 1984 – Hamtramck (Wayne County)

A fire at a chemical plant involved exploding tanks of anhydrous ammonia, forcing the evacuation of 300 people from the scene. Several firefighters were injured.

May 12, 1988 – Detroit (Wayne County)
A chemical fire (involving sulfur chloride) at a manufacturing plant forced the evacuation of persons living around the plant.

October 24, 1988 – St. Clair Shores (Macomb County)
A chemical spill at a plant injured 40 persons and forced an evacuation of the site.

November 29, 1988 – Flint Twp. (Genesee County)
A fire at a plastics plant created a toxic plume that forced the evacuation of 75 homes. A total of 97 firefighters were injured while fighting the blaze, and 20 required hospitalization.

April 22, 1990 – Egelston Twp. (Muskegon County)
A release of phosphorus oxychloride from a plant created a toxic plume that covered a two-mile area, forcing the evacuation of 1,000 people from two mobile home parks.

March 27, 1998 – Brighton (Livingston County)
A fire at a plastics plant burned for 16 hours, injuring two persons, forcing the evacuation of 50 homes, and closing of US-23 for several hours. One-third of the plant was destroyed.

October 29, 1999 – Livonia (Wayne County)
An explosion and flash fire at a chemical plant released a plume of chromic acid over a nearby residential area and freeway, forcing 40 people to seek medical treatment at nearby hospitals. Persons within a quarter-mile radius of the plant were advised to stay indoors and keep doors and windows closed. A 1.5-mile stretch of Interstate 96 was closed for several hours, to allow for air monitoring and testing.

January 12, 2000 – Livonia (Wayne County)
An ammonia leak inside a food processing plant caused an explosion and fire that tore out the side of the building, injured three persons, forced the evacuation of 12 employees, and closed nearby roads for approximately 9 hours. The cleanup effort was complicated by the discovery that the leaked ammonia had mixed with water, creating a solution of ammonium hydroxide that can cause severe burns to skin and eyes, and in some cases, death. An environmental firm was brought in to clean up the solution.

April 12, 2000 – Egelston Twp. (Muskegon County)
An explosion and flash fire at a chemical plant injured 10 persons and flattened part of the plant's production area. The explosion is believed to have been caused by the chemical tetranitromethane, once used to make rocket fuel. Although the plant never produced the chemical, it may have been an unintended by-product of the company's herbicide production. The explosion shook buildings more than a mile from the plant and hurled sections of steel I-beams onto the roof of a nearby factory more than 200 yards away. The cleanup operation forced the evacuation of businesses within a one-half mile safety zone around the plant.

July 14, 2001 – Riverview (Wayne County)
An explosion at a chemical plant killed three plant workers, injured nine others, and forced the evacuation of 2,000 nearby residents. The explosion was caused when methyl mercaptan – a colorless flammable gas used in the manufacture of additives for chicken feed and pharmaceuticals and as an additive to natural gas – seeped from a 25,000-gallon rail car and exploded at the plant. (Methyl mercaptan is a foul smelling gas that can be toxic to humans if they are exposed to heavy concentrations for up to one hour. Exposure to small amounts of the chemical for several hours can cause headaches and burning sensations in the eyes and throat.) The toxic chemical cloud briefly threatened the city of Amherstburg in Ontario, Canada, but a wind shift reduced the threat and the need to evacuate. Fire officials at the scene indicate the situation could have been much worse had another nearby tanker containing methyl mercaptan, and three others containing chlorine, also ignited. Favorable wind conditions also helped push the fumes away from surrounding communities, reducing the need to evacuate more residents.

August 27, 2001 – Detroit (Wayne County)
A fire at a metal plating plant injured eight firefighters, forced the evacuation of residents within a five-block radius, and completely destroyed the plant. The fire, which continued to smolder for more than 24 hours, consumed large tanks of cyanide, sulfuric acid, and other chemicals. Toxic fumes from the fire forced a one-week closure of a local elementary school.

April 9, 2002 – Dearborn (Wayne County)
At least 15,000 gallons of oil was dumped into the Detroit and Rouge rivers, contaminating 27 miles of shoreline. The oil was apparently dumped into a Dearborn storm sewer, but the Environmental Protection Agency was unable to find conclusive evidence to point to one polluter. Federal authorities spent $3.7 million cleaning up the area.

July 7, 2003 – Linwood (Bay County)
A large industrial fire occurred at the American Recycling Company in Linwood. The fire involved butyl rubber (approximately 1,000 bags of 1,000 lbs. each) and 200 barrels of fuel additives. Residents of a mobile home park were evacuated to a safe location.

February 1, 2004 – Sarnia, Ontario (St. Clair River)
39,000 gallons of toxic chemicals leaked into the St. Clair River near Sarnia, Ontario. Methyl ethyl ketone and methyl isobutyl ketone, which are low toxicity solvents, leaked into the river from an Imperial Oil plant. Local residents were urged to refrain from using the tap water for cooking, bathing, or drinking, until the water could be tested.

October 16, 2007 – Melvindale (Wayne County)
Residents and three schools were evacuated after a leak was reported at a Melvindale chemical company, totaling nearly 3,000 evacuated residents. Hydrochloric acid was released into an overflow container, so it was not a direct spill. It was released into a container and was contained by Hazmat teams.

September 15, 2007 – Lowell (Kent County)
A fire and an explosion destroyed several connected buildings at a Lowell factory. The fire affected a quantity of 10% solution of sulfuric acid that was between 5 and 10 thousand gallons. There was a concern over the effect on groundwater, and on the Lowell municipal water supply. The blaze sent black and gray smoke billowing high into the evening sky, visible at least 10 miles away, and attracted hundreds of onlookers. A half-dozen area fire departments, from as far as East Grand Rapids and Belding, helped Lowell firefighters battle the blaze. There was at least one reported injury.

December 14, 2007 – Fraser (Macomb County)
A truck spilled 550 gallons of sulfuric and nitric acid in Fraser, closing a boulevard. Local businesses were evacuated and crews conducted a total cleanup of the area. The Clinton Township hazardous materials team arrived on the scene and determined that all of the truck's contents had emptied, some of which had run off the road and into a nearby sewer and drain. No one was injured in the incident.

July 18, 2008 – Grand Blanc (Genesee County)

Residents near a Grand Blanc plant were evacuated when several tanks filled with sulfuric acid caught fire. Police were called to the plant and most of the fires were quickly under control. However, firefighters were concerned about hazardous vapors in the air and began evacuating residences and businesses. One tank continued to burn from the inside, making it difficult for firefighters to put the flames out.

September 25, 2008 – Grand Haven (Ottawa County)

A small leak from a faulty plug in a one-ton sulfur dioxide tank, delivered to the Grand Haven wastewater treatment plant, forced authorities to evacuate about 75 homes for three hours. The plug had a faulty thread, allowing the liquid substance to escape and immediately turn to gas. There were no reported injuries or effects from the gas release.

March 9, 2009 – Detroit (Wayne County)

The Detroit Fire Department handled a chemical spill clean-up after an undetermined amount of sulfur dioxide had leaked from a railroad car in southwest Detroit. The leak happened at a city wastewater treatment plant just west of Zug Island. The car was carrying about 90 tons of sulfur dioxide, but it was unclear how much leaked out. A professional chemical handling company oversaw the transfer of the remaining sulfur dioxide to another railcar.

July 10, 2010 – Monroe County

Southbound I-75 was closed during the early morning hours because of a chemical spill at a Toledo industrial park. Although the spill was outside of the state, there was still an effect upon one of Michigan's major Interstate highways.

February 15, 2012 – Edwardsburg (Cass County)

An old fertilizer and bulk chemical facility burned down in Edwardsburg, with thick clouds of smoke billowing out for about two hours.

March 10, 2012 – Adrian (Lenawee County)

A large fire occurred at a plastics recycling facility, causing a nearby sports game at Siena Heights University to be called off at half-time in order to avoid the risk of having smoke affect the spectators. Nearby residents were asked to shelter indoors, due to the huge amounts of smoke generated from the blazing 8,000 square-foot structure. High winds made firefighting challenging, and during the several hours that it took for more than a dozen area fire departments to contain the blaze, one firefighter received a minor injury and was transported to a hospital for treatment.

June 24-25, 2013 – Plainwell (Allegan County)

On June 24th an operational process within the Drug & Laboratory Disposal, Inc. plant created a chemical reaction that resulted in a fire at the business. Their staff activated their contingency plans and contacted 911, bringing the Plainwell Department of Public Safety to the scene. Several additional fire departments responded to the incident, and the fire was extinguished by late afternoon. During the night hours, however, another chemical reaction caused the fire to rekindle. An evacuation ordered was issued for the nearby residents and businesses. The second fire was extinguished during the early morning hours of June 25th. US Environmental Protection Agency (EPA) and MDEQ staff were included in the response and investigation. The evacuation order was lifted on the afternoon of June 25th.

Programs and Initiatives

Note: Many of the programs and initiatives designed to mitigate, prepare for, respond to, and recover from hazardous material transportation incidents have the dual purpose of also protecting against fixed-site hazardous material incidents and some industrial accidents. As a result, there is some overlap in the narrative "Programs and Initiatives" sections for each respective hazard. This redundancy allows each hazard section to stand alone, eliminating the need to refer to other hazard sections for basic information.

Superfund Amendments and Reauthorization Act (SARA), Title III

As explained earlier, the Bhopal, India tragedy initiated a chain of events aimed at enhancing preparedness activities to minimize the potential for a similar event to occur in the United States. On October 17, 1986 the Superfund Amendments and Reauthorization Act (SARA) was signed into law. A major SARA provision is Title III (the Emergency Planning and Community Right-To-Know Act, also known as SARA Title III), which establishes hazardous material emergency planning, reporting, and training requirements for federal, state and local governments, and private industry. In Michigan, the SARA Title III program is jointly administered and implemented by two state departments—the Michigan State Police and the Michigan Department of Environmental Quality.

The emergency planning provisions of SARA Title III require each state to establish a state emergency response commission, emergency planning districts, and a local emergency planning committee for each district. The state commission and local committees are responsible for preparing and implementing emergency plans, as well as receiving and disseminating copies of material safety data sheets, chemical inventories, and other reports and forms necessary for compliance under the Act. The community right-to-know provisions of SARA Title III allow the public to access information on the hazardous materials stored in their community, and the quantities of toxic materials released into the environment.

State Emergency Response Commission

The Michigan Emergency Planning and Community Right-to-Know Commission (commonly known as the State Emergency Response Commission or SERC) was established in 1987 and then re-organized in 1994 and 1995. It consists of 17 members appointed by the Governor. The membership includes several state agencies, the general public, and a variety of other groups and professional disciplines (including agriculture, industry, labor, education, local government, and environmental protection and stewardship). The SERC is chaired and administered by the Emergency Management and Homeland Security Division, Department of State Police (EMHSD/MSP), in cooperation and conjunction with the Michigan Department of Environmental Quality (MDEQ). The primary purpose of the SERC is to monitor SARA Title III activities in the state and develop policy and overall direction for program administration. The EMHSD/MSP and MDEQ provide professional staff to assist the SERC in carrying out Title III planning, training, exercising and reporting activities.

Local Emergency Planning Committees

One of the major provisions of SARA Title III is the establishment of Local Emergency Planning Committees (LEPCs) for designated planning districts. The LEPCs are responsible for developing emergency response plans for communities that have facilities in their jurisdiction subject to SARA Title III emergency planning requirements. The LEPC is the primary mechanism through which local SARA Title III planning, training and exercising activities are implemented. Michigan has 88 designated LEPCs – one for each of the 83 counties and 5 in major cities. Nearly 2,800 facilities across the state have been identified as being subject to Title III emergency planning provisions. A facility is subject to SARA Title III provisions if extremely hazardous substances (as determined by the U.S. Environmental Protection Agency) are present at the facility in quantities at or above the minimum threshold quantities established in Section 302 of the Act. The map at the end of this section provides a breakdown of Title III (Section 302) sites by county.

Individual firms doubtlessly vary a great deal in their safety records, just as they vary in the types and quantities of hazardous materials that they handle. Use of GIS can be helpful since Section 302 sites can be located spatially and then ringed with a buffer representing the identified evacuation zone. A vulnerability assessment would primarily be based on the development that exists within that zone—especially if vulnerable populations are located within that area, such as schools, hospitals, other medical facilities such as blood banks or kidney dialysis centers, high-rise senior facilities, and day care centers. The probability of a local incident might be assessed from historical records of industrial accidents or chemical releases. Wide variation in estimates is likely, depending on whether the history of an entire industry or only of a particular site is used. Often, a local site may appear to have an incident-free history, but the risk cannot be assumed to be zero.

Hazardous Material Response Planning

Each Section 302 site must be covered by a community response plan that addresses the emergency planning requirements found under SARA Title III. Inclusion of Michigan Firefighter Right-to-Know provisions of the Michigan Occupational Health and Safety Act (1986 PA 80) is also encouraged in the planning guidance provided by the Emergency Management and Homeland Security Division, Department of State Police. The EMHSD/MSP provides technical planning assistance to the LEPCs to facilitate the development and maintenance of those required plans. That assistance typically includes provision of written planning guidance, interaction with the planning team, plan reviews, and limited financial assistance (via federal grant funds) to offset the costs of preparing the plans. Each facility plan must address the following critical areas: 1) hazard identification (to include chemical inventories, locations, release detection, and chemical-specific response information); 2) vulnerability map and analysis (to include a vulnerability zone, special populations affected, and other facilities and areas that may contribute to risk); 3) population protective actions (to include warning, access control, evacuation and in-place sheltering); 4) response procedures (to include both on-site and off-site expertise and equipment); and 5) a training and plan exercising program. The plans must be reviewed and commented upon by the Michigan SERC.

The Michigan Department of Environmental Quality and the Michigan Department of Agriculture and Rural Development provide technical information and planning assistance in the areas of community-right-to-know, material safety data sheets, chemical inventories, incident reporting, and (on a limited basis) incident cleanup.

Hazardous Material Response Training

The Emergency Management and Homeland Security Division, Department of State Police, provides a wide array of hazardous material response training programs through the Michigan Hazardous Material Training Center. The Center provides training courses for individuals and companies responsible for planning, inspection, response, mitigation, and cleanup activities involving hazardous materials. Specific subjects include: 1) computer-aided management; 2) hazardous materials chemistry; 3) hazardous materials emergency response; 4) hazardous waste worker compliance; 5) incident management; 6) hazardous materials monitoring/sampling; and 7) other specialized hazardous materials-related courses such as highway and rail cargo tanker handling, confined space entry, emergency medical services, and technical rescue. Courses are conducted at the Center in Lansing and at various other locations throughout the state.

Federal/State Hazardous Material Response Resources

Even prior to the Bhopal, India incident in 1984, there were numerous groups at the federal, state, and local levels, and in private industry, trained to deal with hazardous material incidents. Those groups include the National Response Team (NRT), Regional Response Teams (RRTs), and state and local hazardous material response teams. The Chemical Manufacturers Association established the Chemical Transportation Emergency Center (CHEMTREC) to provide 24-hour technical advice to emergency responders. The National Response Center (NRC), which operates much like CHEMTREC, was established to provide technical advice and coordinate federal response to a hazardous material incident.

In Michigan, a 24-hour statewide notification system called the Pollution Emergency Alerting System (PEAS) was established for reporting chemical spills to the Department of Environmental Quality. As a companion to the PEAS, the Michigan Department of Agriculture and Rural Development (MDARD) has established a 24-hour Agriculture Pollution Emergency Hotline for use by agri-chemical users to report fertilizer and pesticide spills. Callers to the MDARD hotline gain immediate access to appropriate technical assistance, regulatory guidance for remediation, and common sense approaches for addressing the problem.

U.S. EPA Chemical Emergency Preparedness and Prevention Office

The USEPA's Chemical Emergency Preparedness Office (CEPPO) provides leadership, advocacy and assistance to states, local governments, and private industry to: 1) prevent and prepare for chemical emergencies; 2) respond to environmental crises; and 3) inform the public about chemical hazards that may be present in their community. The CEPPO works closely with several Michigan state agencies to implement and coordinate a number of regulatory and non-regulatory programs designed to protect human health and the environment in Michigan from chemical accidents—including the SARA Title III program.

Resource Conservation Recovery Act

Not all facilities with hazardous materials fall under the requirements of SARA Title III. The Michigan Department of Environmental Quality (MDEQ) regulates over 8,000 small and large hazardous waste generators under the federal Resource Conservation Recovery Act (RCRA). The RCRA provides MDEQ with the authority to control hazardous waste from "cradle to grave," which includes the generation, transportation, treatment, storage, and disposal of hazardous waste. The high number of RCRA facilities in Michigan is indicative of the widespread prevalence of hazardous materials throughout the state.

Michigan Chemical Council

The Michigan Chemical Council is the primary trade association representing the chemical and allied industries in Michigan. As such, it works in partnership with the national Chemical Manufacturers Association, the Emergency Management and Homeland Security Division of the Department of State Police (MSP/EMHSD), and

other agencies and local governments to provide educational and community outreach services in the area of chemical awareness and safety. The Council provides an important informational and coordination bridge between Michigan's chemical industries, federal, state and local regulatory agencies, and the public.

Chemical Awareness Week

Each spring, the MSP/EMHSD, in conjunction with several other state agencies, LEPCs, and the Michigan Chemical Council, sponsors Chemical Awareness Week. This annual public information campaign focuses on: 1) the hazards associated with the manufacture, transport, storage, use, and disposal of chemicals; 2) the programs and systems in place to protect the public from accidental chemical releases; and 3) community emergency response procedures for chemical accidents. Informational materials on chemical hazards and safety are disseminated to schools, hospitals, nursing homes, other interested community groups and facilities, and the general public.

Mitigation Alternatives for Fixed Site Hazardous Material Incidents

- Compliance with/enforcement of Resource Conservation and Recovery Act (RCRA) standards.
- Elimination of clandestine methamphetamine laboratories through law enforcement and public education.
- Identification of radioactive soils and high-radon areas
- Proper separation and buffering between industrial areas and other land uses.
- Location of industrial areas away from schools, nursing homes, etc.
- Public warning systems and networks for hazardous material releases.
- Increased coverage and use of NOAA Weather Radio (which can provide notification to the community during any period of emergency, including large scale hazardous material incidents).
- Compliance with all industrial, fire, and safety regulations.
- Insurance coverage.
- Enhanced security and anti-terrorist/sabotage/civil disturbance measures.

Tie-in with Local Hazard Mitigation Planning

Because many means of implementing mitigation actions occur through local activities, this updated MHMP places additional emphasis on the coordination of State-level planning and initiatives with those taking place at the local level. This takes two forms:

1. The provision of guidance, encouragement, and incentives to local governments by the State, to promote local plan development, and
2. The consideration of information contained in local hazard mitigation plans when developing State plans and mitigation priorities.

Regarding the first type of State-local planning coordination, MSP guidance has included the "Local Hazard Mitigation Planning Workbook" (EMD-PUB 207), which is currently being updated for release by 2015. For the second type of State-local planning coordination, a section later in this plan summarizes hazard priority information as it has been reported in local hazard mitigation plans. Here, it will merely be noted that hazardous material incidents were identified as one of the most significant hazards in the county hazard mitigation plan for St. Clair County. (Various communities within other counties may have designated this hazard as significant, but the local concerns do not necessarily make the hazard more serious than other ones faced at the county level.) In the case of the City of Port Huron (and St. Clair County, in which it is located) the key distinction seems to be the proximity of the very large "Chemical Valley" site in Sarnia, Ontario. This site is located just across the St. Clair River, and small-to-moderate scale hazardous material releases are frequently reported from this site, usually going into the waters of the river. According to an online emergency management plan for the City of Sarnia (page 14), a reciprocal aid agreement is in place with the City of Port Huron. The Ontario Hazard Analysis was examined as part of the MHMP update process, and it states that Sarnia has "the largest cluster of facilities that produce or use large quantities of chemicals in Canada."

SARA Title III Sites in Michigan

Source: Michigan Department of Environmental Quality

NUCLEAR POWER PLANT EMERGENCIES

An actual or potential release of radioactive material at a commercial nuclear power plant, in sufficient quantity to constitute a threat to the health and safety of the off-site population.

Hazard Description

Though the construction and operation of nuclear power plants is closely monitored and regulated by the Nuclear Regulatory Commission (NRC), accidents at these plants are considered a possibility, and appropriate on-site and off-site emergency planning is conducted. An accident could result in the release of potentially dangerous levels of radioactive materials into the environment and could affect the health and safety of the public living near the nuclear power plant. A nuclear power plant accident might involve both a release of airborne radioactive materials and radioactive contamination of the environment around the plant. The degree and area of environmental contamination could vary greatly, depending on the type and amount of release, and the weather conditions that are present. Response to a nuclear power plant accident requires specialized personnel who have been trained to handle radioactive materials safely, who have specialized equipment to detect and monitor radiation, and who are trained in personal radiation exposure control.

After a period of decline following the 1979 Three Mile Island accident and the 1986 incident at Chernobyl, there is a recent renewed interest in nuclear energy because it could partially address problems of dwindling oil reserves and global warming, with far fewer emissions of greenhouse gases than the use of fossil fuels. However, the use of nuclear power is controversial because of the problems of storing radioactive waste for indefinite periods, the potential for radioactive contamination by accident or sabotage, and the possibility that its use could in some countries lead to the proliferation of nuclear weapons. As the chart below shows, the United States produces the most nuclear energy of any country in the world, but many other countries actually use nuclear energy as a larger percentage of their overall energy production.

Nuclear Electricity Generation by Country: 2008

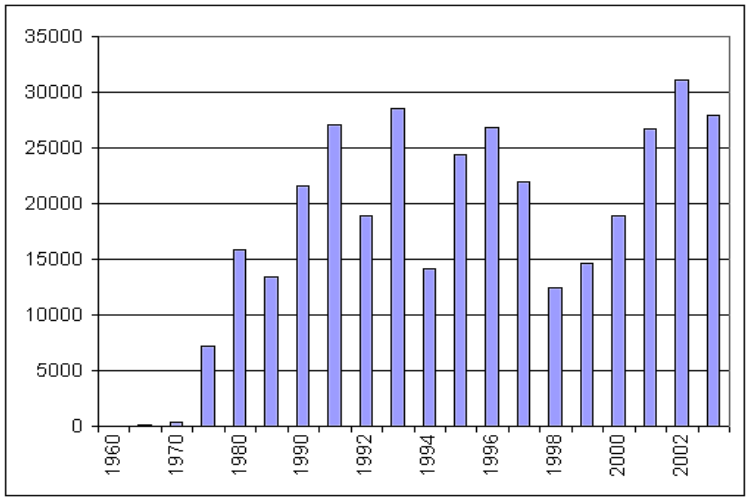
Country	Production (Billion Kilowatt Hours)	% of Country's Energy	Country	Production (Billion Kilowatt Hours)	% of Country's Energy
Argentina	6.9	6.2%	Korea RO (South)	144.3	35.6%
Armenia	2.3	39.4%	Lithuania	9.1	72.9%
Belgium	43.4	53.8%	Mexico	9.4	4.0%
Brazil	13.2	3.1%	Netherlands	3.9	3.8%
Bulgaria	14.7	32.9%	Pakistan	1.7	1.9%
Canada	88.3	14.8%	Romania	10.3	17.5%
China	65.3	2.2%	Russia	152.1	16.9%
China: Taiwan	39.3	17.1%	Slovakia	15.5	56.4%
Czech Rep.	25.0	32.5%	Slovenia	6.0	41.7%
Egypt	0	0%	South Africa	12.8	5.3%
Finland	22.1	29.7%	Spain	56.5	18.3%
France	419.8	76.2%	Sweden	61.3	42%
Germany	140.9	28.8%	Switzerland	26.3	39.2%
Hungary	13.9	37.2%	Turkey	0	0%
India	13.2	2.0%	Ukraine	84.5	47.4%
Indonesia	0	0%	United Kingdom	48.2	13.5%
Iran	0	0%	**USA**	**806.7**	**19.7%**
Israel	0	0%			
Japan	241.3	24.9%	**WORLD**	**2,597.8**	**14%**
Korea DPR (North)	0	0%			

Hazard Analysis

With three commercial nuclear power plants currently operating in the state, emergency preparedness is required in all potentially affected jurisdictions. Michigan's three commercial nuclear power plants are 1) the Enrico Fermi-2 plant near Monroe; 2) the Donald C. Cook plant near Bridgman; and 3) the Palisades plant near Covert.

A fourth plant, the Big Rock Point plant near Charlevoix, was closed in 1997 and then decommissioned, but spent fuel is still stored on-site in dry casks and will probably remain there quite a while. The Davis-Besse nuclear power station near Toledo, Ohio has several Michigan counties within its Secondary Emergency Planning Zone (EPZ), requiring coordinated planning between Michigan and Ohio. The commercial power plant facilities are located on the map at the end of this section. The chart below shows the amount of nuclear power that Michigan has generated since 1960.

Nuclear Generation in Michigan, 1960 through 2003
(Million Kilowatt Hours)



Source: Energy Information Administration, State Energy Data Report 1999, Electric Power Annual (Volume 1, 2001), and EIA Survey Form 906.

Federal, state and local governments and utility personnel take extensive precautions to ensure that, should a nuclear accident occur, its impact on the safety and well being of the general public and the environment will be minimal. These precautions include the development and continual testing of emergency plans, training of response personnel, coordination of response actions, and development and dissemination of emergency public information. A regular series of large, interagency drills and exercises takes place for each nuclear plant, and each plant has two designated emergency planning zones—primary (within a 10 mile radius) and secondary (within a 50 mile radius)—to handle all possible incidents and response activities that could be anticipated, both in the short-term and the long-term.

Impact on the Public

A nuclear power plant accident would tend to pose limited threats, directly involving the environment and public over a distance typically no greater than 10 miles away, even in the most severe U.S. events. Evacuation and contamination may occur within this limited distance from the plant, and any more far-reaching effects (e.g. food chain contamination) would vary with weather conditions and the extent and type of radioactive release. This hazard has been extensively studied and prepared for, allowing the likely impacts on the public to be efficiently assessed and addressed, should an event occur.

Impact on Public Confidence in State Governance

A nuclear power plant emergency may severely affect public confidence in state government if it results in significant environmental harm, displacement, or casualties. Although the odds of this happening are slim, nuclear power is poorly understood by many U.S. citizens, many of whom may be expected to misinterpret both the nature of the industry as well as the effects of an accident, and to perceive that any significant failures are likely the result of inadequate governmental oversight and regulation.

Impact on Responders

Due to pre-planning, training, and exercising, a nuclear power plant accident offers the opportunity to use planned staging areas, from which to handle equipment, protective clothing, medical treatment, decontamination, provision and sheltering needs. Responder exposure to radiation should not need to exceed amounts that have been mandated by law and by workplace regulations. (Extensive procedures and regulations are in place to minimize those types of risks.)

Impact on the Environment

A nuclear power plant accident could result in the release of potentially dangerous levels of radioactive materials both in the air and around the plant. Contamination may occur from radioactive gases, liquids or particles. Some possible accidents at nuclear power plants pose a risk for severe environmental contamination, and the degree and area of this contamination could vary greatly depending on the type and amount of radioactivity, and on the weather conditions.

An accidental release of large amounts of radioactive contamination could contaminate many areas of land for long periods of time, making it unusable for humans, wildlife species, and natural vegetation. The main reason is due to radioactive materials comprising unstable isotope elements that decay over a long period of time. Some isotopes can decay quickly, while others take a very long time to stabilize. Certain radioactive elements such as plutonium can remain hazardous for thousands of years, making re-use of an area difficult or hazardous. Nuclear reactors produce high level waste (an actual classification) in the reactor core that is highly reactive and thermally hot, presenting handling, transportation, and storage problems. Radioactive contamination may affect nearby water bodies, rivers, etc. and damage the environment and its aquatic life. Radioactive material has the potential to seep deep into the ground and water table.

Significant Nuclear Power Plant Accidents

Worldwide, four nuclear power plant accidents rank as most significant in the history of the nuclear power era:

September 29, 1957 – "Kyshtym Disaster" near Chelyabinsk, Russia

The Mayak Nuclear facility, which was a nuclear fuel reprocessing plant located in the sealed-off town that is now called Ozyorsk. (Kyshtym was, at the time, the officially named city that was located nearest to the disaster.) An exploding chemical tank blasted radioactive materials skyward, which drifted with the winds to the northeast. Materials from this blast were scattered for about 200 miles along a line where the winds blew, and contaminated the area with caesium-137 and strontium-90. An estimated 270,000 persons were exposed to radioactive materials as a result, and twenty communities were eventually resettled away from this contamination zone. The full extent of this event was only revealed to the public decades later, starting in the 1970s.

March 28, 1979 – Three Mile Island, Harrisburg Pennsylvania

On March 28, 1979, the most serious nuclear reactor accident ever to occur at a commercial power plant in the United States took place at the Three Mile Island nuclear power plant near Harrisburg, Pennsylvania. This incident resulted from a plant malfunction, combined with operator overrides of automatic safety systems. These errors resulted in a partial meltdown of the reactor core. Utility, state, and local personnel implemented response plans to protect the public in the area around the plant, while on-site efforts were undertaken to cool the reactor and prevent any possible release of radioactive material. While this accident did not result in any off-site health consequences, it had a major impact on emergency planning regulations in the United States.

Following the accident, new federal regulations were written to mandate specific activities by both on-site and off-site emergency response organizations. These more stringent federal regulations aimed at improving emergency planning efforts at nuclear power plants and providing for additional plant safety systems. Among the new regulations was NUREG 0654/FEMA REP-1, which forms the basis for state and local government planning, training, and emergency exercises. The U.S. Environmental Protection Agency (EPA) also issued new guidance on environmental monitoring and protective actions.

April 26, 1986 – Chernobyl, Ukraine (then part of the Soviet Union)

On April 26, 1986 a Soviet nuclear reactor at Chernobyl, Ukraine suffered a steam explosion while conducting experimental testing. This explosion, and the ensuing fire in the graphite core of the reactor, released radioactive debris into the upper atmosphere, where wind currents dispersed it around the world. Other radioactive material was deposited in areas around the plant site, contaminating the land and food. The high levels of radiation on-site killed 32 plant workers and firefighters. The World Health Organization and other public health agencies are still studying the effects of the accident on public health in the Ukraine and nearby areas.

The long-term impacts of this accident are continuing today. The area within a 30 kilometer (20 mile) radius around the plant is heavily contaminated with radioactive material, and most of those who had previously resided there have not returned. Soil contamination does not allow the consumption of crops grown in these areas. Because residents had consumed contaminated crops and milk, studies have indicated significant increases in childhood thyroid cancer in the region around the plant. 4.5 million persons continued to live in less-severely contaminated areas in Ukraine, Russia, and Belarus. One of the major lessons learned from this accident is the need for early impoundment of suspected food and milk that may have been contaminated. The EPA has revised its guidelines for environmental monitoring in affected areas as a result of the Chernobyl experience.

While an event of this nature is not physically possible at a U.S. reactor due to differences in reactor design and safety systems (for example, the Chernobyl reactor did not have a containment building), the event did impact U.S. emergency planning regulations. Lessons learned from this accident have been incorporated into federal guidance (e.g., EPA 400 Ingestion Pathway Protective Action Guidance). Additional emphasis has been placed on the ingestion pathway aspects of nuclear power plant emergency exercises.

March 11, 2011 – Japan

On March 11, 2011 a 9.0 magnitude undersea mega-thrust earthquake occurred near Tohoku, Japan. The epicenter was approximately 43 miles east of the Oshika Peninsula of Tohoku and the hypocenter was at an underwater depth of approximately 20 miles. It was the most powerful known earthquake to have hit Japan, and one of the five most powerful earthquakes in the world since modern record-keeping began in 1900. There were multiple foreshocks, as well as hundreds of aftershocks of a 4.5 magnitude or greater. The earthquake triggered extremely destructive tsunami waves of up to 40.5 meters high, and in some cases traveling up to 6 miles inland in Tohoku. The Japanese National Police Agency has confirmed (as of 2012) 15,854 deaths, 26,992 injuries, and 3,155 people missing; as well as 129,225 buildings destroyed, and 945,970 damaged. The earthquake and tsunami caused extensive and severe structural damage in Japan, heavy damage to roads and railways, fires in many areas, and a dam collapse. Around 4.4 million households in northeastern Japan were left without electricity. The earthquake also moved Honshu 8 feet east and shifted the Earth on its axis an estimated 4 to 10 inches.

In addition to loss of life and destruction of infrastructure, the tsunami caused a number of nuclear accidents, primarily equipment failures, the release of radioactive materials, and level 7 meltdowns at three reactors in the Fukushima I Nuclear Power Plant complex. The Fukushima I, Fukushima II, Onagawa Nuclear Power Plant, and Tōkai nuclear power stations, consisting of a total of eleven reactors, were automatically shut down following the earthquake. Three nuclear reactors suffered explosions due to hydrogen gas that had built up within their outer containment buildings after cooling system failures. At Fukushima I and II, tsunami waves overtopped seawalls and flooded the entire plant, including low lying generators, electrical switch gears, and external pumps for supplying cooling seawater. The plant's connection to the electrical grid was broken because the tsunami destroyed the power lines. All power for cooling was lost and the reactors started to overheat from the natural decay of the fission products created before shutdown. The flood destroyed diesel backup power systems, leading to severe problems at Fukushima I, including three large explosions and radioactive leakage. Flooding with radioactive water also prevented access to basement areas where repairs where needed. Officials from the Japanese Nuclear and Industrial Safety Agency reported that radiation levels inside the plant were up to 1,000 times normal levels, and that radiation levels outside the plant were up to eight times normal levels. Residents within a 12 mile radius of the Fukushima I Nuclear Power Plant and a 6 mile radius of the Fukushima II Nuclear Power Plant were evacuated. There were associated evacuation zones that affected hundreds of thousands of residents.

An April 7, 2011 aftershock caused the loss of external power to Rokkasho Reprocessing Plant and Higashidori Nuclear Power Plant, but backup generators were functional. Onagawa Nuclear Power Plant lost 3 of 4 external power lines and lost its cooling function for as long as 80 minutes. It was also reported that radioactive iodine and cesium was detected in the tap water in several nearby areas. Radioactive strontium was detected in the soil in some places in Fukushima as well. It was estimated that the release of dangerous radioactive isotopes of iodine and cesium from Fukushima reached almost the same emission levels as those from Chernobyl in 1986. Food products were also found to be contaminated by radioactive matter in several places and food grown in the area was banned from sale. As the nuclear crisis entered a second month, experts recognized that Fukushima I was not the worst nuclear accident ever (compared to Chernobyl, which was worse) but it was the most complicated, due to the multiple reactors involved. Later analysis indicated that three reactors (Units 1, 2, and 3) had suffered meltdowns and continued to leak coolant water three months after the initial events.

Experts have said that a workforce in the hundreds or even thousands would take years or decades to clean up the area. It was announced that the plant would be decommissioned once the crisis was over. Early estimates placed insured losses from the earthquake alone at US$14.5 to $34.6 billion. The overall earthquake and tsunami event cost is estimated by the World Bank to be US$235 billion, making it the most expensive natural disaster on record. Even the United States suffered damage because, in California and Oregon, up to 8 foot high tsunami surges hit some areas, damaging docks and harbors and causing over $10 million in damages.

Michigan experienced a significant nuclear power plant incident in 1966, although nothing along the lines of the Chernobyl, Three Mile Island, and Japan accidents in terms of scope, magnitude, or severity:

October 5, 1966 – Enrico Fermi-1, Monroe County, Michigan

Although Michigan has never experienced a significant nuclear power plant accident that involved an off-site release of radioactive material, on October 5, 1966, a serious incident did occur at Detroit Edison's then-new Enrico Fermi Atomic Power Plant near Monroe (commonly called Fermi-1). Fermi-1 was an experimental breeder reactor designed to demonstrate the feasibility of liquid fast-metal breeder reactor technology. On October 5, a metal flow guide inside the reactor broke off and blocked the flow of sodium coolant in the space below the reactor core. As a result, approximately 1% of the fuel melted. The fuel damage caused the release of some radiation into the reactor containment building; however, no off-site release occurred. The plant was eventually repaired, and it operated for a short period until it was permanently shut down in 1972. The fuel and related materials were removed and sent to a federal government facility in the mid-1970s. The Enrico Fermi-2 nuclear power plant opened next door in 1988.

March 5, 2002 – Davis-Besse, Oak Harbor, Ohio

An incident occurred on March 5, 2002 at the Davis-Besse Nuclear Power Station in Oak Harbor, Ohio when maintenance workers discovered that corrosion had eaten a football-sized hole into the plant's reactor vessel head. Although the corrosion did not lead to an accident, the Nuclear Regulatory Commission kept the plant shut down until March 2004. The U.S. Justice Department investigated and penalized the owner of the plant $28 million in fines for safety and reporting violations related to the incident. The NRC also imposed its largest fine ever, more than $5 million, against First Energy for the actions that led to the corrosion.

In February, 2014, the Davis-Besse Plant has temporarily been shut down for maintenance operations. It is not known when the plant will reactivate, but there are plans to spend at least $600 million to upgrade the plant. The plant is currently licensed until 2017, and a successful renewal of that license would be good for an additional 20 years.

Programs and Initiatives

Since the Three Mile Island accident in 1979, federal, state and local governments have developed detailed radiological emergency response plans for each nuclear power plant based on NUREG 0654/FEMA REP-1 and subsequent federal regulations and guidance. These plans are exercised on a biennial basis and are reviewed by the Federal Emergency Management Agency (FEMA) and the Nuclear Regulatory Commission (NRC).

Ownership and use of radioactive materials is strictly regulated by the federal government. Nuclear power plants must follow strict building and safety codes. Material storage, use, and waste management practices are strictly monitored. In 1977, President Carter placed a moratorium on the shipping of spent fuel from commercial nuclear power plants to burial sites or spent-fuel reprocessing centers. Spent fuel is now stored at the plant site in spent fuel pools or dry cask storage facilities until the issue of permanent nuclear waste disposal is resolved.

Response to a nuclear power plant accident in Michigan is the joint responsibility of the plant owner/operator and the federal, state, and local government. State and local governments implement protective actions and other preparedness and response activities, based on the Nuclear Accident Emergency Action Level Classification System. In most cases, the Primary Emergency Planning Zone (EPZ) around a nuclear power plant is 10 miles. Within this zone, plans are developed to protect the public through in-place sheltering and evacuation, in the event of an accident. The area within the Primary EPZ for which protective actions are implemented will depend on the type and amount of radioactive material released, and on weather conditions. The Secondary Emergency Planning Zone, consisting of a 50-mile radius around most plants, exists for planning considerations which aim to prevent radioactive contamination of the food chain.

International Nuclear Event Scale (INES)

The International Nuclear Event Scale is a seven scale level system that is designed to describe event severity in terms of a logarithmic scale in which each level is ten times more severe than the preceding one. After the zero level classification (denoting no significant threat), there are then three levels of "incident" and four levels of "accident," with the most serious being classified as a 7 (major accident). The selection of a level for a given event is based on three parameters: effect on people or the environment, loss of protective radiation barriers, and loss of any of the layers of safety systems. There have only been two Level 7 accidents (Chernobyl in 1986 and Japan in 2011) and only one Level 6 accident (Mayak, in 1957, also in the former Soviet Union). Three Level 5 accidents have also been classified—the Windscale Pile (United Kingdom, in 1957), the Three Mile Island accident in 1979, and the Goiânia accident (Brazil, in 1987, which is described in the Terrorism section of this document, within the subsection that assesses radiological attacks).

Radiological Emergency Preparedness (REP) Program

The Radiological Emergency Preparedness Program is responsible for the development and implementation of Michigan's Nuclear Facilities Emergency Management Plan, and for the nuclear accident aspects of the Michigan Emergency Management Plan, including the Department of Environmental Quality's radiological responsibilities to respond to accidents or emergencies at any of Michigan's commercial nuclear power plants. These efforts are conducted in cooperation with other state agencies and under the overall emergency response coordination responsibilities of the Michigan Department of State Police. Program staff also interacts with nuclear plant utility staff, and personnel from the U.S. Nuclear Regulatory Commission, concerning the day-to-day operations of nuclear power reactors to ensure radiological protection for the public and the environment.

Potassium Iodide (KI) Distribution

The possibility that radiation could be released into the environment during a radiation emergency, such as a nuclear reactor accident, has been a concern for years. The major concern with exposure to whole-body radiation or to heat and debris from a radioactive explosion is massive tissue damage and death from the explosion. Radiation-related thyroid cancer is another possible effect of exposure if radioactive iodine (radioiodine) is released by the accident. It can take 10 years or more after exposure for the thyroid cancer to develop, but it may then require surgery or chemotherapy. Taking potassium iodide (KI) pills in the immediate aftermath of radioiodine exposure can reduce the risk of subsequent thyroid cancer. The pills protect the thyroid from radiation poisoning for 24 hours, which is usually enough time to evacuate to safety. Though the pills won't protect against the other harmful effects of radiation exposure, they are so effective at preventing thyroid cancer caused by this type of radiation that many people and organizations have begun purchasing and stockpiling supplies of this over-the-counter tablet as a precautionary step. The federal government has asked states to consider the distribution of

potassium iodide pills to people who live within 10 miles of nuclear plants, as a precaution against a severe nuclear accident. About 220,000 people in Michigan live within 10 miles of the state's three nuclear power plants. People living or working within 10 miles of any of the three nuclear power plants are able to receive a voucher for a 20-pill pack of potassium iodide (KI pills) at nearby pharmacies, free of charge.

Hazard Mitigation Alternatives for Nuclear Power Plant Emergencies

- Arrangements for designated shelters and accident warning systems.
- Increased coverage and use of NOAA Weather Radio (which can provide notification to the community during any period of emergency, including plant accidents).

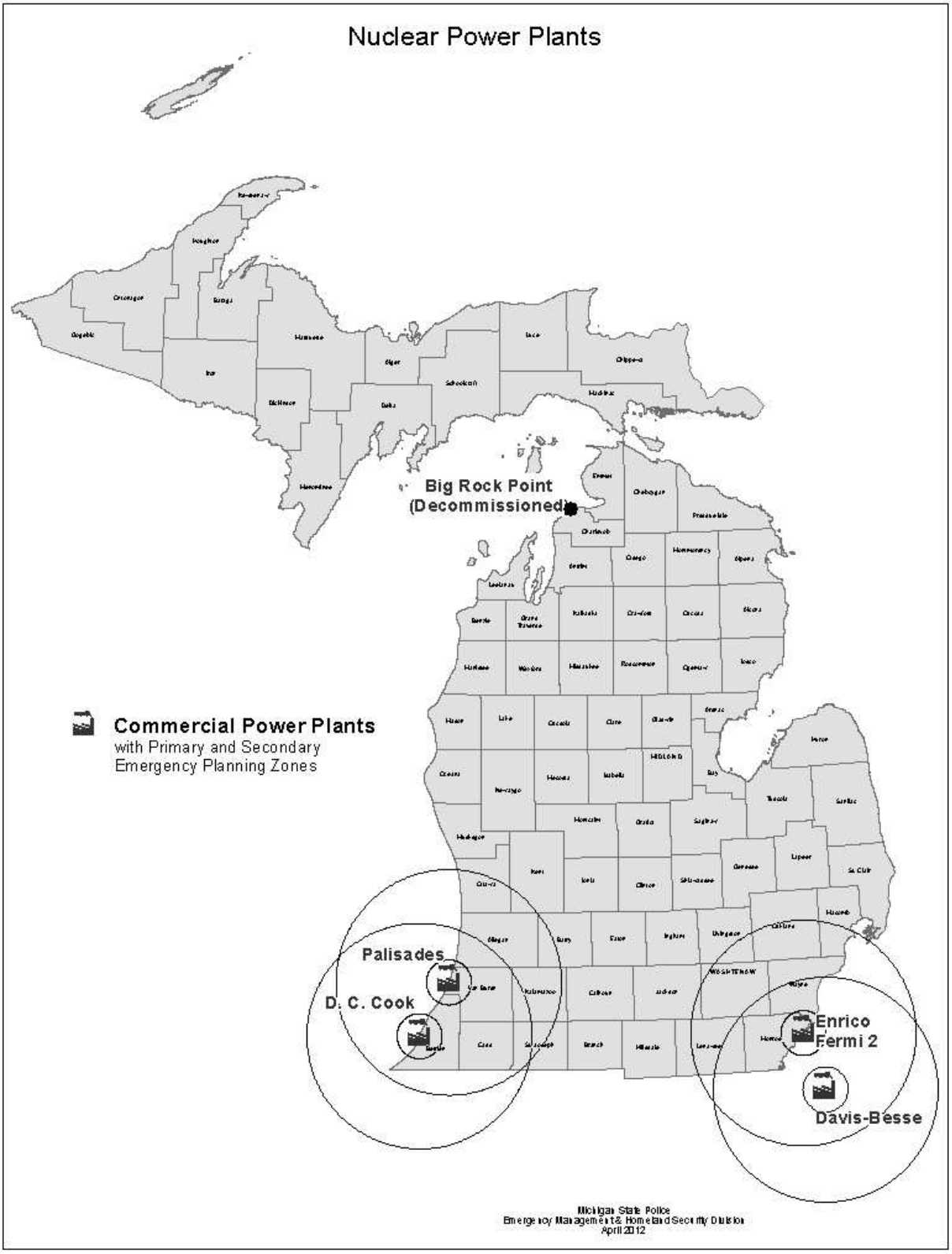
Tie-in with Local Hazard Mitigation Planning

Because many means of implementing mitigation actions occur through local activities, this updated MHMP places additional emphasis on the coordination of State-level planning and initiatives with those taking place at the local level. This takes two forms:

1. The provision of guidance, encouragement, and incentives to local governments by the State, to promote local plan development, and
2. The consideration of information contained in local hazard mitigation plans when developing State plans and mitigation priorities.

Regarding the first type of State-local planning coordination, MSP guidance has included the "Local Hazard Mitigation Planning Workbook" (EMD-PUB 207), which is currently being updated for release by 2015. For the second type of State-local planning coordination, a section later in this plan summarizes hazard priority information as it has been reported in local hazard mitigation plans. Here, it will merely be noted that nuclear plant emergencies were identified as one of the most significant hazards in the local hazard mitigation plan for Cass County.

Nuclear Power Plants in Michigan



HAZARDOUS MATERIAL INCIDENTS: TRANSPORTATION

An uncontrolled release of hazardous materials during transport, capable of posing a risk to life, health, safety, property, or the environment.

Hazard Description

As a result of the extensive use of chemicals in our society, all modes of transportation – highway, rail, air, marine, and pipeline – are carrying thousands of hazardous materials shipments on a daily basis through local communities. A transportation accident involving any one of those hazardous material shipments could cause a local emergency affecting many people.

Hazard Analysis

Michigan has had numerous hazardous material transportation incidents that affected the immediate vicinity of an accident site or a small portion of the surrounding community. Those types of incidents, while problematic for the affected community, are fairly commonplace. They are effectively dealt with by local and state emergency responders and hazardous material response teams. Larger incidents, however, pose a whole new set of problems and concerns for the affected community. Large-scale or serious hazardous material transportation incidents that involve a widespread release of harmful material (or have the potential for such a release) can adversely impact the life safety and/or health and well-being of those in the area surrounding the accident site, as well as those who come in contact with the spill or airborne plume. In addition, damage to property and the environment can be severe as well. Statistics show that almost all hazardous material transportation incidents are the result of an accident or other human error. Rarely are they caused simply by mechanical failure of the carrying vessel.

Being surrounded by the Great Lakes, one of the most dangerous hazardous material transportation accident scenarios that could occur in Michigan would be a spill or release of oil, petroleum or other harmful materials into one of the lakes from a marine cargo vessel. Such an incident, if it involved a large quantity of material, could cause environmental contamination of unprecedented proportions. Fortunately, the Great Lakes states, working in partnership with oil and petroleum companies and other private industry, have taken significant steps to ensure that a spill of significant magnitude is not likely to occur on the Great Lakes. (See the Programs and Initiatives section for more information.)

(Note: Pipeline transportation accident issues are addressed in the Petroleum and Natural Gas Pipeline Accidents section of this document. Refer to that section for specific information on that hazard. For an assessment of the various types of potential impacts from this hazard, please refer to the introductory section on hazardous materials, preceding the section on fixed site hazardous materials, earlier in this document.)

The maps at the end of this section illustrate the major railroads, highways, and Great Lakes ports in the State of Michigan. These transportation links and nodes have the greatest probability of experiencing a hazardous material transportation incident. Although the greatest risk involving hazardous materials comes from highway and rail shipments, a petroleum or chemical spill on the Great Lakes could have disastrous consequences for shoreline communities, recreational areas, tourism, and the environment. Fortunately, only about 3% of all shipments on the Great Lakes involve petroleum or chemicals, and most of those are through the Port of Detroit.

Significant Hazardous Material Transportation Incidents

Michigan has been fortunate not to have a large-scale, serious hazardous material transportation incident. However, Michigan has had numerous smaller-scale hazardous material transportation incidents that required a response by local fire departments and hazardous material teams, and many events also required evacuations and other protective actions. As a major manufacturer, user, and transporter of hazardous materials, Michigan will always be vulnerable to the threat of a serious hazardous material transportation incident.

From 1994 through 1998, local fire chiefs in Michigan reported a total of 730 hazardous material incidents on the Michigan Fire Incident Reporting System (MFIRS). Of those 730 reported incidents, approximately 25-30% (about 200 incidents) involved some form of motorized vehicle transportation. That figure represents an average of one reportable hazardous material transportation incident statewide approximately every 9.1 days. (Note: 1998 is the last year for which statewide hazardous material incident response statistics are available.)

A reportable hazardous material incident is one in which all three of the following conditions apply: 1) a material is present that is suspected to be something other than ordinary combustible by-product material; 2) the material is in such a state, quantity or circumstance that, if left unattended, it is presumed to pose a threat to life, health, property or the environment; and 3) special hazardous material resources were dispatched or used, or should have been dispatched or used, for assessing, mitigating or managing the situation.

Selected Significant Hazardous Material Transportation Incidents in Michigan since 1978

February 4, 1978 Woodland Park (Newaygo County)
A freight train derailment caused a chemical spill of ethylene oxide, carbolic acid, methylene chloride, and phropheline oxide. A total of 50 persons were evacuated from the vicinity of the accident scene.

July 31, 1978 Milan (Monroe County)
A fuel tanker accidentally pumped 1,000 gallons of gasoline into Milan's sewer system, resulting in an explosion. A total of 1,500 persons were evacuated from a 50 square block area until the system could be adequately flushed out to prevent the threat of additional explosions.

August 27, 1978 Farmington Hills (Oakland County)
A commercial van containing radioactive material (iridium 192) was involved in an accident. The van caught on fire, prompting fears of a serious radiological incident. Traffic was re-routed around the accident site until it was determined that no leakage of radioactive material had occurred.

January 11, 1979 Frankenmuth Twp. (Tuscola County)
A freight train derailment involving liquid petroleum gas forced the evacuation of 75 persons in the vicinity of the accident site.

June 22, 1979 Newaygo (Newaygo County)
A freight train derailment caused a chlorine leak that eventually sealed itself. A total of 300 persons were evacuated as a precautionary measure.

November 12, 1979 Holland Twp. (Ottawa County)
A freight train derailed, causing a spill of hydrogen fluoride. The accident prompted the evacuation of 1,500 persons.

February 18, 1981 River Rouge (Wayne County)
A freight train derailed, carrying 56,000 gallons of liquid propane gas, and resulted in a precautionary evacuation of over 6,000 persons. Fortunately, a serious spill was averted.

February 27, 1981 Dayton Twp. (Tuscola County)
A freight train derailed, spilling hydrochloric acid, liquid petroleum gas, isobutane, and butylene. The derailment prompted the evacuation of 60 persons living in the vicinity of the accident site.

August 7, 1981 Bridgman (Berrien County)
A freight train derailment resulted in a spill of fluourosulfonic acid, which formed a vapor cloud that forced the evacuation of 1,000 persons. A State Police trooper died as a result of breathing the toxic fumes.

March 15, 1982 Fruitport Twp. (Muskegon County)
A freight train derailment caused a spill of chlorine and caustic acid, forcing 600 persons to evacuate the accident vicinity.

April 11, 1982 St. Joseph (Berrien County)
A freight train derailed near St. Joseph, causing a spill of ethylene benzoil and benzine. The accident prompted the evacuation of 500 nearby residents until the spill could be contained and cleaned up.

December 28, 1982 Chesterfield Twp. (Macomb County)
A tanker truck began leaking nitric acid, which resulted in 12 injuries from product exposure and forced the evacuation of 1,200 persons in the surrounding area, due to the toxic fumes.

February 1, 1983 Coopersville (Ottawa County)
A gasoline tanker truck rolled over on I-96 near Coopersville, resulting in a spill of 9,000 gallons of gasoline. The gasoline then caught on fire, forcing the closure of I-96 for several hours until the fire could be suppressed and the site cleaned up and restored.

October 12, 1983 Fraser (Macomb County)
A tanker truck overturned, spilling 5,000 gallons of methyl amyl ketone. The spill forced the evacuation of 600 persons, and M-97 and 14 Mile Road were closed until the spill could be cleaned up and the site restored.

October 12, 1984 Thompson Twp. (Schoolcraft County)
A gasoline tanker truck swerved to avoid hitting a school bus and rolled over, spilling approximately 7,000 gallons of gasoline and 1,000 gallons of diesel fuel. The accident prompted the evacuation of 30 persons until the spill could be cleaned up and the site restored.

April 25, 1989 Highland Twp. (Oakland County)
A freight train thought to be carrying hazardous materials derailed, prompting the evacuation of residents within one half mile of the accident site (including a high school). It was later determined that the tank cars were not filled and only material substance residue was present in the cars. However, emergency workers at the scene felt the remaining residue posed a danger to the community. The accident site was cleaned up and the evacuees were allowed to return later that day.

July 22, 1989 Tittabawassee Twp. (Saginaw County)

A freight train carrying a variety of hazardous materials derailed near Freeland, causing two rail cars to catch on fire and forcing a weeklong evacuation of over 1,000 residents. One home near the accident site was destroyed by the fire. After the fire was extinguished one week later, the site was cleared and the contaminated soil surrounding the site was excavated and transported to a hazardous waste landfill. After all hazardous conditions and health concerns were alleviated, the evacuation was lifted and evacuees were allowed to return to their homes.

July 29, 1989 Otsego/Bailey Twps. (Otsego County)

A semi-trailer carrying acetic acid, potassium hydroxide and ammonium thiocyanate rolled over on I-75, just south of Gaylord. The accident caused the evacuation of approximately 150 people from nearby homes and businesses. Traffic on I-75 had to be rerouted for the duration of the 12-hour event. No injuries were reported.

January 12, 1990 Buena Vista Twp. (Saginaw County)

A semi-tanker carrying 5,000 gallons of gasoline and 5,000 gallons of diesel fuel overturned due to icy roads and high winds. Approximately 2,500 gallons of diesel fuel spilled into the drain system and traveled an estimated ¾ mile before it could be diked and removed by an environmental cleanup contractor. The spill prompted the evacuation of approximately 520 persons in a half-mile radius. The evacuated area was re-opened 12 hours later, after the cleanup was completed.

March 12, 1990 Dearborn and Detroit (Wayne County)

A leak of the chemical copper chloride from a delivery truck prompted the evacuation of several homes and businesses on the Dearborn-Detroit border. No injuries were sustained in the incident, but the roadway was closed for several hours while cleanup operations were completed. Copper chloride is a corrosive that is hazardous to touch, and the fumes can cause respiratory problems.

September 16, 1990 Bay City (Bay County)

The tanker vessel Jupiter exploded and caught fire while moored in Bay City's harbor. The vessel was carrying approximately two million gallons of unleaded gasoline. The fire burned for several days. After the fire was extinguished, the remaining petroleum product had to be pumped out of the cargo hold–a difficult and risky task–and sent to a treatment facility. This incident created a concern for the safety of the residents in the vicinity of the fire, for response personnel who had to extinguish a shipboard fire, and for the river environment. In addition, river commerce was disrupted for an extended period of time because of the incident. A Governor's Emergency Declaration was granted to provide supplemental state assistance in the containment and suppression of the fire, and the required environmental monitoring during the transfer of the remaining gasoline to another tanker vessel.

March 24, 1993 Sylvan Twp. (Washtenaw County)

A semi truck carrying DCT acid drove off of I-94, one mile west of M-52, and struck a tree. The collision caused approximately 220 gallons of the material to leak from the vehicle onto an area on and near the roadway. Two police officers and two motorists were injured due to exposure to the product, and all were hospitalized for a brief time. Interstate 94 was closed for several hours to avoid any further exposure to the chemical.

November 16, 1994 Morrice & Perry (Shiawassee County)

A fire aboard a freight train carrying sodium isopropyl xanthate prompted an evacuation of residents in the immediate vicinity of the railroad tracks, on the outskirts of Morrice. The fire burned for approximately 10 hours before it was completely extinguished and area residents were allowed to return to their homes.

April 5, 1995 Detroit (Wayne County)

A tractor trailer transporting 8,500 gallons of gasoline overturned on a ramp at I-94 and I-75. The driver was killed in the crash and ensuing fire. A one-half mile area around the crash scene was evacuated, due to the risk of explosion from seeping gas that washed down into the sewer.

June 4, 1999 Whitehall (Muskegon County)

At a tannery, a tanker truck driver unloaded (unknowingly) a shipment of sodium hydrosulfide solution into a storage tank normally used exclusively for ferrous sulfate solution, creating a chemical reaction that produced hydrogen sulfide – a poisonous gas. The truck driver was pronounced dead at the scene after having been overcome by the hydrogen sulfide gas. An employee of the tannery was rendered unconscious by the gas, but regained consciousness in time to avoid lasting, serious injury. Eleven employees at the tannery were evacuated. Total property damage was in excess of $411,000.

August 29, 1999 Birmingham and Bloomfield Twp. (Oakland County)

More than 40 cars of a 98-car freight train carrying automobiles and some hazardous materials (yellow phosphorous) derailed in Birmingham and Bloomfield Township, causing two rail cars to catch on fire and forcing police and fire officials to warn nearby residents and motorists to stay indoors and keep their windows closed, due to possible toxic fumes. None of the cars containing hazardous materials derailed. Some local roads were closed for several hours. The derailment caused an estimated $6 million in damage.

September 7, 1999 Ecorse (Wayne County)

A four-car freight train derailment that included a tanker car carrying 23,000 gallons of ethylene oxide forced an evacuation of 600 persons from nearby homes, businesses, and schools on the Ecorse-River Rouge border. The tanker car was inspected and determined not to be leaking. After several hours, the train cars were uprighted and the evacuated residents were allowed to return to the area.

January 21, 2000 Flint (Genesee County)

A rail car with 33,000 gallons of liquid propane gas caught fire in the CSX rail yard in Flint, forcing the evacuation of 2,600 homes within a one-mile radius of the incident site. The danger of a potential explosion also shut down a section of I-475 and closed two elementary schools near the scene. An estimated 3,500 evacuees were housed in three shelters and local motels until the incident was stabilized the next day. CSX railroad and local fire officials determined that the best course of action was to separate the burning tanker from the 54 other liquid propane tanker cars, vent the tanker, and allow the remaining product to burn off.

May 27, 2000 Detroit (Wayne County)

A semi-tanker carrying 13,000 gallons of gasoline overturned, ignited, and exploded on I-75 in downtown Detroit, killing the driver and forcing the cancellation of the city's Memorial Day parade that was to be held nearby. The parade was cancelled because officials feared that fuel entering the sewer system could ignite and launch manhole covers into the crowd. Firefighters pumped foam and water into storm drains to prevent further explosions. The stretch of I-75 involved in the accident was closed for several hours to allow for cleanup activities.

July 14, 2001 Riverview

A pipeline attached to a fitting on the unloading line of a railroad tank car fractured and separated, causing the release of methyl mercaptan, a poisonous and flammable gas. Shortly after, the tank car ignited and sent a fireball 200 feet into the sky. Fire damage to cargo transfer hoses on an adjacent tank car

resulted in the release of chlorine, a poisonous gas that is also an oxidizer. Three plant employees were killed in the accident. About 2,000 residents were evacuated from their homes for about 10 hours.

November 15, 2001 Springfield Twp. (Oakland County)

Two freight trains – one carrying a tanker of chloride gas – collided head on and derailed in rural Springfield Township, killing two train crewmen and critically injuring two others. The crash ignited the swampland around the accident site as three of the four locomotives derailed and caught on fire. The accident forced the evacuation of 100 homes within a half-mile radius (for several hours) and closed two nearby schools for the day. Fortunately, the tanker of chloride gas did not leak.

May 27, 2002 Potterville

A horizontal break in a railroad track running through Potterville caused the derailment of 35 cars from a 58-car Canadian National Railroad freight train. Nine cars contained liquid propane, two of which leaked the gas. About 2,200 citizens were evacuated for up to four days. Canadian National Railroad reimbursed residents who could document losses such as missed work, spoiled food, and hotel stays.

January 29, 2003 Flint

A truck hauling propane gas plunged from a freeway overpass and exploded on top of a set of railroad tracks, killing the driver and cutting off power to 1,100 people. Interstate 69 was closed in both directions for several hours because of this incident.

February 24, 2003 Holland Twp. (Ottawa County)

Four tanker trucks exploded and burned at an oil company in Holland Township. The blaze injured four people who were rushed to the hospital to be treated for burns and smoke inhalation. A warehouse nearby also reportedly caught fire, but firefighters were able to extinguish the blaze within an hour.

August 8, 2003 Pittsfield Twp (Washtenaw County)

A stretch of Interstate 94 was closed in both directions due to a chemical leak from a tractor-trailer. Formaldehyde was leaking from a tractor-trailer onto the freeway and hazardous materials officials determined that a cap on the truck was loose and fell off, or had never been placed, causing the spill. Two people were exposed to the vapor when driving through the spill, were treated at the scene, and released.

August 27, 2003 Barry County

A tanker transporting 13,500 gallons of gasoline overturned and spilled approximately 5,900 gallons. One person was hospitalized, seven homes were evacuated, M-37 was shut down and gasoline threatened to, but did not, seep into a county drain leading to a lake.

September 16, 2003 Detroit (Wayne County)

A collision between a car and a tanker resulted in an explosion at an I-75 overpass on Detroit's southwest side. The tanker was carrying 22,000 gallons of gasoline, and burned for several hours. The truck's driver had been pulled to safety before the explosion.

October 6, 2003 Detroit (Wayne County)

A tanker explosion and fire killed the tanker's driver and closed nearby expressway ramps for about six months. The fire was extremely intense (estimated at 2400 degrees Fahrenheit), and gasoline leaked and burned over a stretch of about one mile, causing I-94 to be closed down in that area.

October 21, 2003 Detroit (Wayne County)

A rollover accident involving a tractor-trailer closed a major freeway interchange. Hazardous materials crews worked to clear the westbound ramp from Interstate 94 to Interstate 75, following the crash. About 40 gallons of fuel spilled and about 40,000 pounds of coiled steel also spilled onto the freeway ramp.

December 17, 2003 Marysville (St. Clair County)

A stretch of Interstate 94 in St. Clair County was closed after a tractor trailer carrying hazardous materials rolled over. Hazardous materials crews were called because the tractor trailer involved was hauling plastic chemicals.

January 28, 2004 Van Buren County

A tanker truck collided with a pickup truck, spilling ethyl alcohol onto I-94. About 150 people were evacuated within a half-mile radius of the scene. One person was killed during the incident.

March 15, 2004 Taylor (Wayne County)

A collision between a pickup and a tanker truck caused an explosion at Telegraph Road and I-75 in Taylor. Flames reached 400 feet in the air, and the driver of the pickup truck was killed. Telegraph Road was closed for several hours as the scene was investigated and cleared.

August 13, 2004 Coloma (Berrien County)

Hazardous materials crews closed an eight-mile stretch of both lanes of Interstate 94 after two tractor-trailers collided and resulted in several loud explosions. One of the trucks was transporting Drano, which spilled onto the freeway. One of the drivers was injured in the crash and taken to a hospital.

January 7, 2005 Detroit (Wayne County)

A collision between a jeep and tanker truck resulted in the tanker overturning on northbound I-75. The tanker spilled an estimated 5,000 gallons of flammable xylene and toluene liquid, requiring the freeway to be closed for several hours. The driver of the jeep was injured, but no evacuations were required.

September 13, 2005 Detroit (Wayne County)

A collision between a car and tanker on I-275 caused the tanker to roll over into the median. Hazardous materials crews responded, due to leaking chemicals that are used in asphalt manufacture. The driver of the car was killed, and the driver of the tanker suffered minor injuries. Lane closures on the freeway continued through the afternoon rush hour.

July 7, 2006 Tustin (Osceola County)

A semi truck overturned on US-131 in an accident involving ethanol fuel near Tustin in Osceola County. Both lanes of the highway were shut down. Over 2,000 gallons of fuel contaminated the soil, resulting in about 10,000 gallons of sludge being removed by the hazardous materials teams.

December 14, 2007 Fraser (Macomb County)

A sulfuric acid spill of 550 gallons from a vacuum truck shut down an intersection during rush-hour traffic in Fraser. Some of the chemical leaked into a nearby field and may have gotten into a sewer drain. Several businesses in the area were evacuated.

August 28, 2007 Wixom (Oakland County)

Approximately 5,000 to 10,000 gallons of nitric acid leaked when the driver was forced to stop quickly, due to a traffic jam. Two buildings were evacuated during the clean-up process.

January 10, 2008 Detroit (Wayne County)

A liquid propane tanker hauling approximately 7,200 gallons of butane plunged through an overpass guardrail. The resulting explosion damaged a section of northbound Interstate 75, set nearby homes on fire, melted a school playground, and killed the driver. One home was completely destroyed, and many others were damaged. Two northbound lanes of I-75 were closed for several weeks, due to severe structural damage to the concrete overpass pillars.

January 31, 2009 Dearborn (Wayne County)

A hazardous materials situation occurred when a tanker truck slid on ice (created by a broken water main) and overturned in Dearborn. Fuel was spilled on the roadway and ran off into storm drains. Crews sprayed the fuel on the road with foam and took several hours to pump fuel out of the drains. About 100 homes were evacuated.

July 15, 2009 Hazel Park (Wayne County)

A collision between a car and a gasoline tanker on I-75 caused an explosion. The gasoline tanker contained 13,000 gallons of fuel, and the explosion caused the Nine Mile Road overpass to collapse, crushing a passing tractor-trailer. The drivers of the three involved vehicles each suffered minor injuries. Thick smoke and flames shot up 150 to 200 feet in the air, melting the overpass structure. Investigators said that the temperatures reached 2300 degrees. MDOT spent 5 months clearing debris, replacing the bridge, and replacing stretches of concrete that had been compromised as a result of extreme heat. The total cost for the repairs was about $12 million.

May 19, 2010 Brighton (Livingston County)

A semi trailer truck carrying a load of hazardous material overturned on Interstate 96, near Brighton, and closed all lanes of traffic around the accident site, leading to significant traffic delays for hours. The 18-wheeler was traveling eastbound and carrying 70 barrels of Monolube 3400, a potentially hazardous lubricant used in tire manufacturing. Monolube 3400, if shaken in unventilated containers, could produce hydrogen gas that could explode. The truck driver had a collision with a passenger car, and the impact of the rollover truck accident spilled several of the barrels of the Monolube 3400 out onto the roadway. The truck driver was sent to the hospital with injuries, and a hazardous materials team was called to handle the clean up at the scene.

July 3, 2010 Flint (Genesee County)

A semi-tanker and a motorcycle collided on southbound I-475 and the tanker exploded shortly afterwards. The heat from the explosion was so intense that it melted construction barrels and damaged the concrete. The tanker explosion sent a huge fireball into the sky and flames could be seen for miles. The man riding the motorcycle was killed, but the truck driver survived the explosion. Both sides of the expressway were shut down as hazardous materials teams were called to deal with the toxic spill.

July 14, 2010 Romulus (Wayne County)

A vehicle exiting I-275 North at westbound Interstate 94 clipped a semi truck, causing the semi to lose control and roll on its side. The truck was hauling several different chemicals that are used to make detergent, but one of the chemicals leaking was hydrogen peroxide. Many frustrated motorists experienced long waits in traffic, because of delays in transferring the remaining materials to another vehicle. High heat and humidity were also a challenge for the two hazardous materials teams, but there were only minor injuries.

February 1, 2012 – Blackman Township (Jackson County)

An Amtrak train collided with a semi truck, resulting in spilled acid and diesel fuel, as well as the derailment of the train. Ten persons were injured.

July 19, 2012 Lake Huron (2 miles southeast of Lakeport, St. Clair County)

A dredge sank in about 22 feet of choppy water around 4:35 am on July 19, 2012, spilling diesel fuel that caused airborne odors and shut down about a dozen beaches in St. Clair County. Officials organized a shoreline monitoring system, and reported that the sheen of fuel stretched across an area 1 mile wide and 2 miles long. Although the odor was unpleasant enough to encourage people to stay indoors with their windows and doors shut, the fumes were not sufficient to cause serious health concerns. No one reported any illnesses from these fumes, and the spill did not have any known effects upon downstream water plants. About 800 feet of absorbent boom were used to collect the fuel, with an additional 1200 feet of boom made available as a backup in case it might be needed for shoreline protection. Although the dredge had between 1500 and 2000 gallons of fuel on board, it wasn't known how much went into the lake. The limited amount of fuel that reached the shore had mostly dissipated by the next day.

June 11, 2013 Alanson (Emmet County)

A tanker truck accident took place on US-31 south of M-68, causing about 12,000 gallons of cooking oil to spill out. The oil traveled through drains into the Crooked River, requiring extensive efforts to clean up.

January 2, 2014 Davison Township (Genesee County)

A truck crash and explosion caused I-69 to be closed down for much of the day, area citizens within a 1-mile radius were advised to shelter-in-place, and an evacuation of some nearby homes and businesses also took place. About 12,000 gallons of oil had been transported by the crashed truck, which went over a guard rail, crashed into Irish Road, and exploded. The bridge there was damaged, and the driver of the truck had some minor injuries.

Programs and Initiatives

Note: Many of the programs and initiatives designed to mitigate, prepare for, respond to, and recover from fixed-site hazardous material incidents have the dual purpose of also protecting against hazardous material transportation incidents. As a result, there is some overlap in the narrative programs and initiatives descriptions for each respective hazard. This redundancy allows each hazard section to stand alone, eliminating the need to refer to other hazard sections for basic information.

Federal Hazardous Material Transportation Regulations

The transportation, manufacturing, storage, and disposal processes for hazardous materials are highly regulated by federal and state agencies in order to reduce risk to the general public. At the federal level, the U.S. Department of Transportation, Office of Hazardous Materials Safety (USDOT/OHMS), is the regulating agency for all modes of hazardous material transportation. In addition to enforcing federal hazardous material transportation

regulations, the USDOT/OHMS is also involved in a number of other areas aimed at improving the safety of hazardous material shipping. Those areas include: 1) the research and development of improved containment/packaging and other technological aspects of hazardous material shipping; 2) interagency coordination efforts in hazardous material transportation planning and standards setting; 3) management of data information systems pertaining to hazardous material transportation; and 4) development of hazardous material safety training policies and programs. The USDOT regulations specify the type and size of container that can be utilized for shipping each hazardous material, the label that must be on the container, the placards that must be shown on the carrying vessel, how much of the material can be shipped in one vessel, and in some cases how the contents should be organized or loaded. Many hazardous materials are assigned a unique four-digit identification number that is located on the placard or container. In addition, the regulations also require a company involved with hazardous material transport to maintain a manifest that details what material is being transported, its quantity, a list of emergency contact numbers in case of an uncontrolled release, where the material is from, and its intended destination. In Michigan, the Motor Carrier Division of the Department of State Police oversees, coordinates, and implements the commercial truck safety aspects of the USDOT regulations. The Michigan Department of Transportation oversees programs aimed at enhancing railroad safety and improving the rail infrastructure (which helps reduce the likelihood of a hazardous material rail transportation accident).

Hazardous Materials Transportation Uniform Safety Act

The federal Hazardous Materials Transportation Uniform Safety Act (HMTUSA), enacted in 1990, provides funding for the training of emergency responders and the development of emergency response plans for both fixed site facilities and transportation-related incidents. (This funding mechanism under the HMTUSA is referred to as Hazardous Material Emergency Preparedness [HMEP] grants.) In Michigan, the HMTUSA/HMEP program is coordinated and implemented by the Emergency Management and Homeland Security Division, Department of State Police. Since the program's inception, over $3 million in grants have been allocated to 80 Michigan communities for hazardous material planning and training activities.

Transportation Community Awareness and Emergency Response

Many industry groups are involved in an outreach program, coordinated by the Chemical Manufacturers Association, called Transportation Community Awareness and Emergency Response (TRANSCAER). This program is a nationwide community outreach program that addresses community concerns about the transportation of hazardous materials, through planning and cooperation. The program provides assistance to communities to develop and evaluate their emergency response plan for hazardous material transportation incidents. In Michigan, TRANSCAER activities and initiatives are coordinated by the Michigan Chemical Council.

Hazardous Material Response Training

The Emergency Management and Homeland Security Division, Department of State Police, provides a wide array of hazardous material response training programs through the Michigan Hazardous Material Training Center. The Center provides training courses for individuals and companies responsible for planning, inspection, response, mitigation, and cleanup activities involving hazardous materials. Specific subjects include: 1) computer-aided management; 2) hazardous material chemistry; 3) hazardous materials emergency response; 4) hazardous waste worker compliance; 5) incident management; 6) hazardous materials monitoring/sampling; and 7) other specialized hazardous materials-related courses such as highway and rail cargo tanker handling, confined space entry, emergency medical services, and technical rescue. Courses are conducted at the Center in Lansing and at various other locations throughout the state.

Federal/State Hazardous Material Response Resources

There are numerous groups at the federal, state, and local levels, and in private industry, that are trained to deal with hazardous material fixed-site and transportation incidents. These groups include the National Response Team (NRT), Regional Response Teams (RRTs), and state and local hazardous material response teams. The Chemical Manufacturers Association established the Chemical Transportation Emergency Center (CHEMTREC) to provide 24-hour technical advice to emergency responders. The National Response Center (NRC), which

operates much like CHEMTREC, was established to provide technical advice and coordinate the federal response to a hazardous material incident. In Michigan, a 24-hour statewide notification system called the Pollution Emergency Alerting System (PEAS) was established for reporting chemical spills to the Department of Environmental Quality. As a companion to the PEAS, the Michigan Department of Agriculture and Rural Development (MDARD) has established a 24-hour Agriculture Pollution Emergency Hotline for use by agri-chemical users to report fertilizer and pesticide spills. Callers to the MDARD hotline gain immediate access to appropriate technical assistance, regulatory guidance for remediation, and common sense approaches for addressing the problem.

U.S. EPA Chemical Emergency Preparedness and Prevention Office

The U.S. Environmental Protection Agency's Chemical Emergency Preparedness and Prevention Office (CEPPO) provides leadership, advocacy and assistance to states, local governments, and private industry to: 1) prevent and prepare for chemical emergencies; 2) respond to environmental crises; and 3) inform the public about chemical hazards that may be present in their community. The CEPPO works closely with several Michigan state agencies to implement and coordinate a number of regulatory and non-regulatory programs designed to protect human health and the environment in Michigan from chemical accidents—including the SARA Title III program.

National Transportation Safety Board

The National Transportation Safety Board (NTSB) investigates all significant transportation accidents that occur nationwide and issues safety recommendations (to the transporter and to government regulators) aimed at preventing future accidents. To date, five hazardous material transportation accidents in Michigan—the November 15, 2001 freight train accident in Springfield Township, the June 4, 1999 cargo transfer accident in Whitehall, the September 16, 1990 Jupiter tanker fire in Bay City, the July 22, 1989 train derailment in Freeland, and the August 2, 1975 propane pipeline accident in Romulus—have resulted in an NTSB investigation. The NTSB also publishes a list of "most wanted" safety improvements for all modes of transportation, for nationwide implementation by appropriate entities. Although these safety improvement recommendations are not mandatory, and the NTSB has no regulatory or enforcement powers, it nonetheless has been successful in getting more than 80% of its recommendations adopted. Many safety features currently incorporated into the various hazardous material transportation vessels had their genesis in NTSB recommendations. The NTSB works directly with the USDOT on most hazardous material transportation accident issues.

Michigan Chemical Council

The Michigan Chemical Council is the primary trade association representing the chemical and allied industries in Michigan. As such, it works in partnership with the national Chemical Manufacturers Association, the Emergency Management and Homeland Security Division, Department of State Police, and other agencies and local governments to provide educational and community outreach services in the area of chemical awareness and safety. The Council provides an important informational and coordination bridge between Michigan's chemical industry, federal, state and local regulatory agencies, and the public.

Chemical Safety Board (CSB)

The CSB (www.csb.gov) is an independent federal agency charged with investigating industrial chemical accidents. Headquartered in Washington, DC, the agency's board members are appointed by the President and confirmed by the Senate. The CSB conducts root cause investigations of chemical accidents at fixed industrial facilities. Root causes are usually deficiencies in safety management systems, but could be any factor connected with causing or preventing the accident. Accident causes often involve equipment failures, human errors, unforeseen chemical reactions, or other problems. The agency does not issue fines or citations, but does make recommendations to plants, regulatory agencies such as the Occupational Safety and Health Administration (OSHA) and the Environmental Protection Agency (EPA), industry organizations, and labor groups. Congress designed the CSB to be non-regulatory and independent of other agencies so that its investigations might, where appropriate, review the effectiveness of regulations and regulatory enforcement.

Chemical Awareness Week

Each spring, the Emergency Management and Homeland Security Division, Department of State Police, in conjunction with several other state agencies, Local Emergency Planning Committees (LEPCs), and the Michigan Chemical Council, sponsors Chemical Awareness Week. This annual public information campaign focuses on: 1) the hazards associated with the manufacture, transport, storage, use and disposal of chemicals; 2) the programs and systems in place to protect the public from accidental chemical releases; and 3) community emergency response procedures for chemical accidents. Informational materials on chemical hazards and safety are disseminated to schools, hospitals, nursing homes, other interested community groups and facilities, and the general public.

Final Rule on Reflectorization of Rail Freight Rolling Stock

The Final Rule requires railroads and other companies owning rail cars to install yellow or white reflective materials on locomotives over a five-year timeframe and on freight trail cars over a 10-year period. The reflective materials will be installed on all newly constructed locomotives and freight rail cars, and on existing ones, during periodic maintenance repair, unless alternate implementation plans have been developed that meet the deadlines. Nearly one quarter of all highway-rail at-grade crossing collisions involve motor vehicles running into trains occupying crossings. This new rule is the most recent effort by the Federal Railroad Administration (FRA) to increase the visibility of trains at highway-rail at-grade crossings.

Hazard Mitigation Alternatives for Hazardous Material Transportation Incidents

- Improved design, routing, and traffic control at problem roadway areas.
- Long-term planning that provides more connector roads for reduced congestion of arterial roads.
- Railroad inspections, maintenance and improved designs at problem railway/roadway intersections (at grade crossings, rural signs/signals for RR crossing).
- Proper planning, design, maintenance of, and enhancements to designated truck routes.
- Public warning systems and networks.
- Increased coverage and use of NOAA Weather Radio (which can provide notification to the community during any period of emergency, including large scale hazardous material incidents).
- Use of ITS (intelligent transportation systems) technology.
- Locating schools, nursing homes, and other special facilities away from major hazardous material transportation routes.

Tie-in with Local Hazard Mitigation Planning

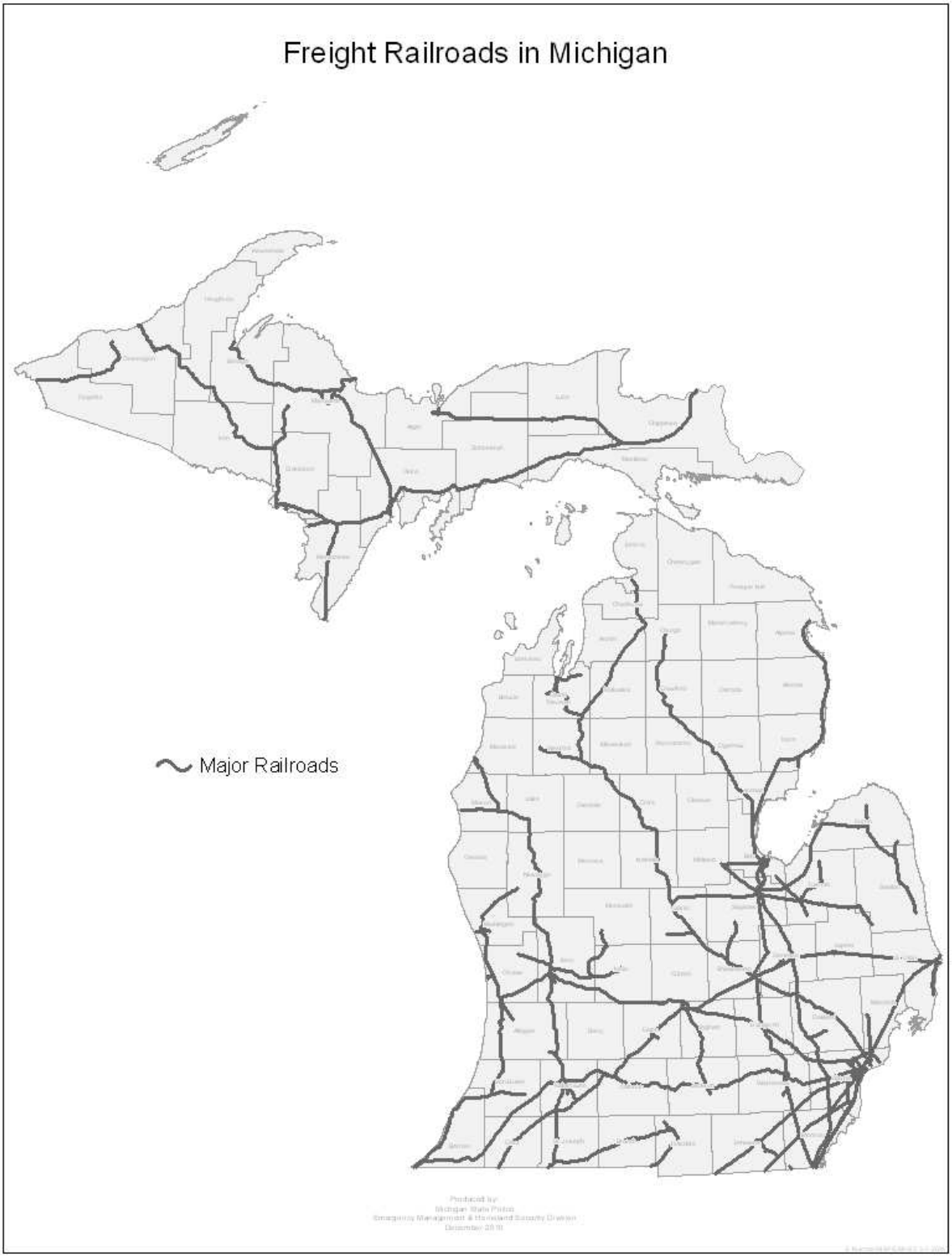
Because many means of implementing mitigation actions occur through local activities, this updated MHMP places additional emphasis on the coordination of State-level planning and initiatives with those taking place at the local level. This takes two forms:

1. The provision of guidance, encouragement, and incentives to local governments by the State, to promote local plan development, and
2. The consideration of information contained in local hazard mitigation plans when developing State plans and mitigation priorities.

Regarding the first type of State-local planning coordination, MSP guidance has included the "Local Hazard Mitigation Planning Workbook" (EMD-PUB 207), which is currently being updated for release by 2015. For the second type of State-local planning coordination, a section later in this plan summarizes hazard priority information as it has been reported in local hazard mitigation plans. Here, it will merely be noted that hazardous materials transportation incidents were identified as one of the most significant hazards in local hazard mitigation plans for the following counties: Cass, Saginaw, St. Clair, Schoolcraft, and Tuscola.

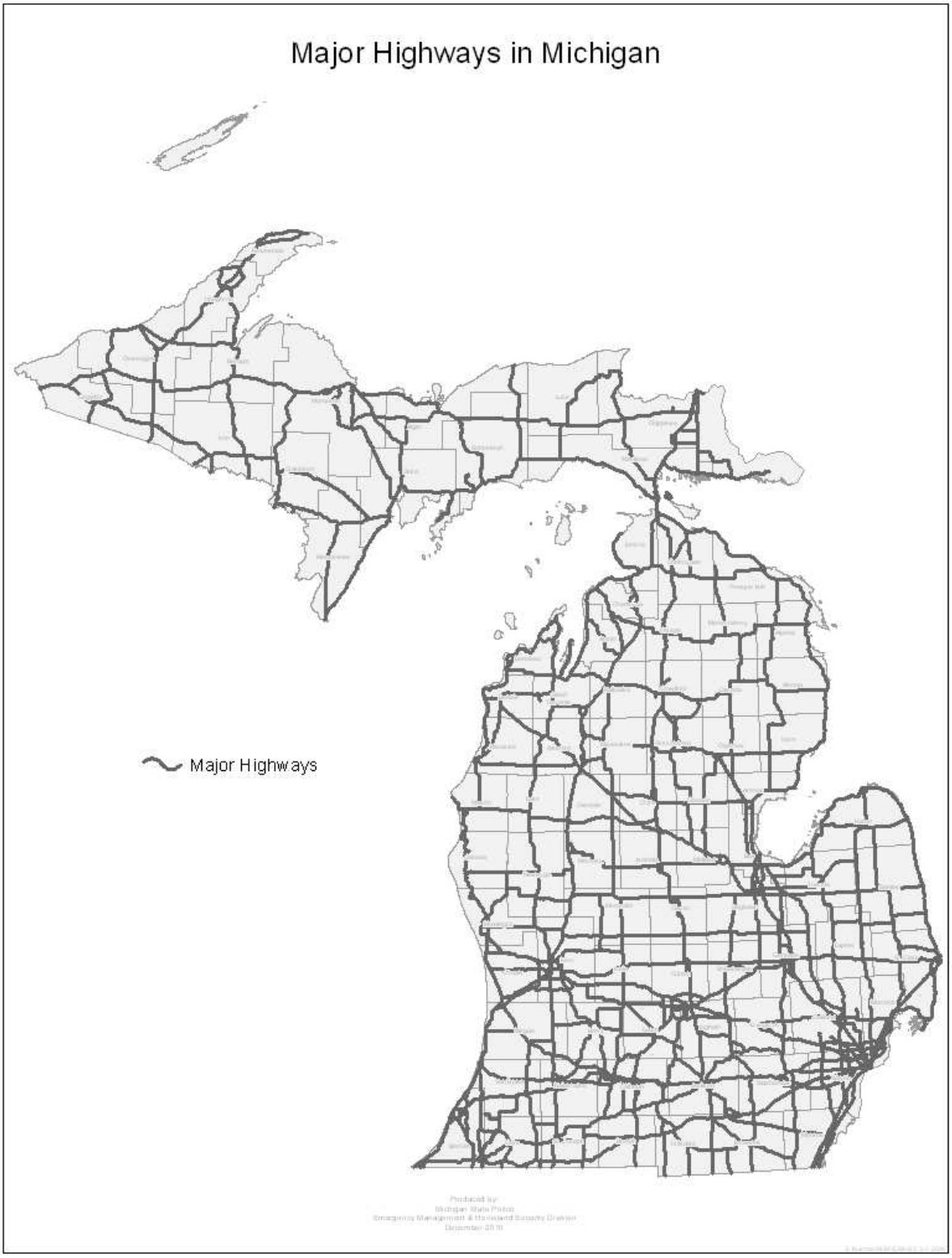
Freight Railroads in Michigan

Source: Michigan Department of Transportation



Major Highways in Michigan

Source: Michigan Department of Transportation



Great Lakes Commercial Ports in Michigan

Source: Michigan Department of Transportation

PETROLEUM AND NATURAL GAS PIPELINE ACCIDENTS

An uncontrolled release of petroleum or natural gas, or the poisonous by-product hydrogen sulfide, from a pipeline

Hazard Description

Though often overlooked, petroleum and natural gas pipelines pose a real threat in many Michigan communities. Petroleum and natural gas pipelines can leak or fracture and cause property damage, environmental contamination, injuries, and even loss of life. The vast majority of pipeline accidents that occur in Michigan are caused by third party damage to the pipeline, often due to construction or some other activity that involves trenching or digging operations. Many structures are located right next to pipelines and thus may be at risk. Pipelines can also cross through rivers, streams, and wetlands, thus posing the possibility of extensive environmental damage in the event of a major failure.

Michigan is both a major consumer and producer of natural gas and petroleum products. According to the federal Energy Information Administration, Michigan's consumption of petroleum products, particularly liquefied petroleum gases (LPG) is high; Michigan is the largest residential LPG market in the nation, due mostly to high residential and commercial propane consumption. The state has a single petroleum refinery but a large network of product pipelines. More than 78% of the overall home heating market uses natural gas as its primary fuel. With over one-tenth of U.S. capacity, Michigan has the greatest underground natural gas storage capacity in the nation and supplies natural gas to neighboring states during high-demand winter months. Driven largely by the residential sector, Michigan's natural gas consumption is high. Nearly four-fifths of Michigan households use natural gas as their primary energy source for home heating.

The State Energy Data System (SEDS) released data in August 2009 that describes energy consumption by source and total consumption per capita. Michigan ranks 13th in the nation in production of natural gas, with 264.9 billion cubic feet, and 7th in consumption, at 847.8 billion cubic feet. These figures underscore the fact that vast quantities of petroleum and natural gas are extracted from, transported through, and stored in the state, making many areas vulnerable to petroleum and natural gas emergencies. Michigan's gas and petroleum networks are highly developed and extensive, representing every sector of the two industries—from wells and production facilities, to cross-country transmission pipelines that bring the products to market, to storage facilities, and finally to local distribution systems.

While it is true that the petroleum and natural gas industries have historically had a fine safety record, and that pipelines are by far the safest form of transportation for these products, the threat of fires, explosions, ruptures, and spills nevertheless exists. In addition to these hazards, there is the danger of hydrogen sulfide (H_2S) release. These dangers (fully explained in the Oil and Natural Gas Well Accidents section) can be found around oil and gas wells, pipeline terminals, storage facilities, and transportation facilities where the gas or oil has a high sulfur content. Hydrogen sulfide is not only an extremely poisonous gas, but is also explosive when mixed with air at temperatures of 500 degrees Fahrenheit or above.

In 2010, Michigan suffered what may be the largest inland oil release in the country, when a pipeline in Calhoun County failed and released large quantities of crude which ended up in the Kalamazoo River and flowed downstream for many miles. Although a description of this event appears later in this section, it must be noted here that because the recovery activities for this disaster are still ongoing, an after-action report was not yet available for use in this analysis, to efficiently relay "lessons learned" and the final results of the extensive cleanup activities.

Hazard Analysis

The map at the end of this section shows the location of major petroleum and natural gas pipelines within Michigan. It is apparent from the map that petroleum and natural gas pipelines crisscross the entire state, from well heads to storage sites, through distribution to consumers. Major compressor stations that receive and redistribute natural gas are located at key points along the pipelines (but are not shown on the map). These stations monitor and maintain pressure levels within the pipelines. In the event of a pipeline rupture, the compressor stations shut down to stop the flow of product. Many smaller compressor stations are located across the state to complete the distribution process to consumers.

The state's major natural gas storage facilities are located in the central part of the Lower Peninsula. Natural gas is piped into those storage facilities from Michigan wells, and from large transmission pipelines that originate in Canada, the southwestern United States, and the Gulf of Mexico area.

Petroleum pipelines carrying crude oil, fuel oil, propane, butane, gasoline, and other petroleum products have their heaviest concentrations in central Lower Michigan and between Detroit and Toledo. Many of the refineries, terminals, and storage areas are located in urban areas where the potential for extensive damage, and threat to lives and property, is greatest. The largest concentration of these facilities is found in the Detroit metropolitan area.

Petroleum and natural gas pipeline accidents are on the rise, due to the aging of the underground infrastructure (much of which was laid over 50 years ago) and an increase in construction excavation. According to studies conducted by the General Accounting Office (GAO), an average of 22 people died annually from 1988 to 1998, when the number of accidents was increasing by four percent per year. The GAO also found that the USDOT/OPS has not adequately enforced many safety regulations passed by Congress since 1988 and is instead relying more on industry self-regulation as an enforcement tool.

Increased pipeline safety regulations again came to the forefront in 2000, after deadly pipeline explosions occurred in Bellingham, Washington in June 1999 (three deaths) and Carlsbad, New Mexico in August 2000 (11 deaths). In 2004, the Pipeline and Hazardous Materials Safety Administration (PHMSA) was signed into law. The purpose of the Act was to provide a more focused research organization and establish a separate operating administration for pipeline safety and hazardous materials transportation safety operations.

The Pipeline Safety Improvement Act of 2002 mandated significant changes and new requirements in the way that the natural gas industry ensures the safety and integrity of its pipelines. The law applies to natural gas transmission pipeline companies. The law places requirements on each pipeline operator to prepare and implement an “integrity management program” that, among other things, requires operators to identify so-called “high consequence areas” (HCA) on their systems, conduct a risk analysis of these areas, perform baseline integrity assessments of each pipeline segment, and inspect the entire pipeline system. Companies were required to identify all HCAs and submit specific integrity management programs to the Office of Pipeline Safety (OPS), the Research and Special Projects Administration, and the U.S. Department of Transportation. All pipeline segments within HCAs were to be inspected and remediation plans completed by December 17, 2008, while non-HCA segments must be inspected by 2012. All segments must be re-inspected on a 7-year cycle, with certain exceptions.

Because petroleum and natural gas pipeline accidents will occur eventually, affected local communities must be prepared to respond to the accident, institute necessary protective actions, and coordinate with federal and state officials and the pipeline company emergency crews to effectively manage and recover from the accident. That can best be accomplished through the collaborative planning, training, and exercising of emergency procedures with all potentially involved parties.

Impact on the Public
Severe events may cause shortages of, and higher prices for, petroleum and other fuels. Some residents with low incomes or fixed budgets may find higher prices to be unaffordable, and may face problems involving heating and other energy needs being used to maintain their homes and health. Transportation and fuel costs may become too expensive to allow business profits to be maintained, when such businesses rely on fuel-driven transportation or functions. Those in the vicinity of the pipeline break itself may suffer from health problems, unpleasant odors, evacuations, and damage/contamination of their property. Some pipeline accidents result in explosions that cause extensive damage, injury and even loss of life. Gas leaks in particular can cause surprising amounts of damage from sudden explosions, without any advance warning to those nearby.

Impact on Public Confidence in State Governance
As with the oil and gas well hazard, there may be a sense that inadequate regulation, authorization, or oversight was maintained by the state, if there is an event of significant size or impact. The nature of the transported materials also causes concern about environmental and health impacts.

Impact on Responders
Special expertise is often needed, and the cooperation of the utility provider is often critical to an efficient and successful response. Enclosed areas may be involved in these incidents (e.g. those occurring in a densely populated urban area), and thus may require special equipment, personnel, and training in search and rescue.

Impact on the Environment
Petroleum and natural gas pipelines pose a real threat in many Michigan communities because they can lead to leaks, fractures, fires, explosions, ruptures, and spills that cause environmental contamination. The danger of hydrogen sulfide (H_2S) release can occur where the gas or oil has a high sulfur content. Hydrogen sulfide is not only an extremely poisonous gas, but is also explosive when mixed with air at temperatures of 500 degrees Fahrenheit or above. Atmospheric concentrations of greenhouse gases, especially carbon dioxide, methane, and nitrous oxide, can contribute to climate change, both regionally and globally. Adverse local consequences to ecological and socio-economic systems can result from a major petroleum or natural gas pipeline accident. Particulate pollutants may consist of metals, soot, or similar small substances. Soft sloping ground near waterway crossings can be susceptible to erosion or lateral spreading, which may cause significant pipe displacement or rupture.

Significant Petroleum and Natural Gas Pipeline Accidents
Petroleum and natural gas pipeline accidents occur with regularity, but they usually have a limited impact and are quickly and adequately handled by pipeline company emergency crews and by local and state responders. According to figures released by the U.S. Department of Transportation's Office of Pipeline Safety (USDOT/OPS), in 1998 (the latest year for which complete data are available) Michigan gas companies had to repair 9,300 leaking underground gas lines. That figure is double the 4,400 reported breaks in 1991. It is estimated that three-quarters of gas line breaks are caused by excavation damage. Many more gas line breaks go unreported, according to regulators from the Michigan Public Service Commission (MPSC). National estimates rank Michigan second only to Texas in the number of repairs to damaged or leaking natural gas pipelines.

Michigan has had numerous petroleum or natural gas pipeline accidents in recent years that resulted in injury, loss of life, or significant property damage. Since 1996, the MPSC has investigated over 100 incidents involving pipelines, and at least half of those incidents involved injury, loss of life, or significant property damage. The pipeline accidents described in this section include the worst in recent Michigan history, which required a combined emergency response effort by pipeline companies and state and local officials.

In 2003 the U.S. Department of Transportation, Research and Special Programs Administration, Office of Pipeline Safety conducted a survey of Natural gas distribution pipeline accidents per state. The state of Michigan

was third overall with 11 recent accidents, trailing only Pennsylvania and California for the highest in the nation. The weighted average for all states was only 2.8 accidents during that time period.

A ten year survey was conducted by the PHMSA of its Pipeline Safety Program Filtered Incident Files, and several other pipeline mileage data sources, to compile a report of significant and serious Michigan incidents involving pipeline accidents from 1999-2008. The results are provided in the table below:

Michigan Pipeline Incidents (all pipeline systems, 1999-2008)

Year	Number	Fatalities	Injuries
1999	16	6	4
2000	5	2	4
2001	5	0	3
2002	5	0	4
2003	13	0	4
2004	5	0	0
2005	7	0	2
2006	9	1	0
2007	1	0	0
2008	7	2	5
Totals	73	11	26
3 Year Average (2006-2008)	6	1	2
5 Year Average (2004-2008)	6	1	1
10 Year Average (1999-2008)	7	1	3
20 Year Average (1989-2008)	7	1	3

Recent Significant Petroleum and Natural Gas Pipeline Accidents in Michigan

NOTE: Natural gas leaks are also a common cause of structural fires, but only some of those incidents (residential house explosions) have been listed here, since most do not rise to the level of community-wide emergency events.

September 7, 1950 Big Rapids (Mecosta County)

A newly installed natural gas pipeline exploded near Big Rapids because of a flaw in the line. Two barns were destroyed and many windows were shaken. The ensuing fire was seen from 50 miles away.

September 26, 1952 Mt Pleasant (Isabella)

Four men were injured in a gas pipeline fire. They had been raising the eight-inch pipeline for reconditioning, when it broke.

May 16, 1967 Dearborn (Wayne County)

A pile driver ruptured a gas line near an underground storage cavern, trapping seven men in a pit with fire at Ford Motor Company's River Rouge Plant. Two of the men were killed and four more were injured. Fire fighters took two hours to bring the blaze under control, and police routed traffic away from the area.

August 2, 1975 Romulus (Wayne County)

On August 2, 1975, an 8-inch pipeline owned by the Sun Pipeline Company ruptured in Romulus. Propane escaped from the rupture, sprayed into the air, vaporized, and then ignited. Flames 500 feet high engulfed an area 600 feet in diameter. The blast created a 12-foot diameter, 7-foot deep hole in the ground. The fire injured nine persons, destroyed four houses and damaged three others, burned 12 vehicles, and consumed 2,389 barrels (100,338 gallons) of propane. The National Transportation Safety Board (NTSB) investigated this accident and determined that the probable cause was the propagation of surface cracks on the pipe, caused by abnormally high pressure within the pipeline at the leak site. The NTSB further found that inadequate inspection during construction had contributed to the accident.

February 22, 1986 Muskegon (Muskegon County)

A Muskegon County pipeline break occurred when an 8-inch high-pressure Marathon Oil pipeline ruptured, spilling thousands of gallons of gas into streams feeding Ruddiman Creek. Gas vapors also caused some minor house explosions that forced dozens of Lakeside-Glenside residents to flee. No one was injured in the incident, although the environment suffered damage.

February 23, 1989 Gratiot County

On February 23, 1989, a Michigan Consolidated Gas Company (MICHCON) underground natural gas pipeline in rural Gratiot County exploded and caught on fire, releasing a vast quantity of gas into the atmosphere. The huge fire necessitated the evacuation of several families from the immediate area. No deaths or injuries occurred. Company officials shut off valves on either side of the break and allowed the remaining gas to burn off.

July 17, 1991 Freeland (Saginaw County)

Workers were removing a corroded segment of a Consumers Power Company's 10-inch-diameter transmission line pipeline. As a segment of the pipeline was being removed, natural gas at 360-psig pressure exerted about 12 tons of force on an adjacent closed valve (H-143), causing it and a short segment of connected pipe to move and separate from an unanchored compression coupling. The force of the escaping gas killed one worker, injured five other workers, and collapsed a steel pit that housed valve H-143. Fortunately, there was no explosion from the natural gas leak.

May 20, 1992 Rochester (Oakland County)

On May 20, 1992, a natural gas explosion occurred in a two-story commercial building in Rochester, killing one person and injuring 17 others. Estimated property damage was nearly $1 million. The explosion occurred when the gas service line to the building was damaged during excavation of a sidewalk. The service line separated under the sidewalk and gas migrated into the building, where it was ignited by an unknown source, causing the explosion.

February, 1996 Napoleon (Jackson County)

In February 1996, a house exploded in Napoleon, resulting in two fatalities. The cause of the explosion was a natural gas build-up.

December 15, 1998 Galesburg (Kalamazoo County)

A natural gas leak caused an explosion in downtown Galesburg in the early morning hours of December 15, 1998, destroying two businesses and damaging a third. One person in an automobile sitting at a nearby red light was slightly injured when a Christmas tree and other debris flew through his windshield. Fortunately, the downtown area was not crowded when the explosion occurred. An eight square block area was evacuated as a precaution, in case of further explosions, but utility workers were able to shut off the gas supply to avert further damage.

January 15, 1999 Whitmore Lake (Livingston County)

A natural gas explosion at a home on January 15, 1999 in Green Oak Township, Livingston County, killed one person, injured four others, and forced the evacuation of 17 residents. The explosion and resulting fire destroyed two homes and damaged several other homes and a business. Subsequent investigation of the incident indicated that a steel gas main in the area was dented, bent, and cracked by a third-party excavation a number of years before it failed.

January 18, 1999 Leslie (Ingham County)

On January 18, 1999, a leaking gas main in Leslie forced the evacuation of two schools (over 1,000 students) and approximately 75 other nearby residents for several hours, until utility workers were able to cap the leak.

March 7, 1999 Plainwell (Allegan County)

On March 7, 1999, a ruptured natural gas transmission line near Plainwell caused an explosion and fire that could be seen for 20 miles away. The explosion and fire occurred in a primarily rural area two miles southeast of Plainwell and about 10 miles north of Kalamazoo. Fortunately, there were no structures nearby, and the explosion and fire did not cause any injuries. The fire, which spread to over 400 feet wide and 100 feet high, burned for nearly two hours before utility workers were able to shut down the gas supply to the line.

June 15, 1999 Battle Creek (Calhoun County)

A natural gas pressure surge caused fires in 24 homes in a 20 block area in Battle Creek on June 15, 1999, resulting in major damage to eight structures and injuries to two persons. The fires forced gas service to be shut off to approximately 1,500 homes for two to three days. Construction work by the natural gas utility caused the gas surge.

June 23, 1999 Lake County

A broken gas main near the intersection of US-10 and M-37 in Pleasant Plains Township, Lake County, forced the evacuation of nearby residences (including senior and low-income housing complexes) until the main could be repaired.

June 25, 1999 Howell (Livingston County)

On June 25, 1999, a ruptured gas main set off an explosion and fires in Howell, destroying one business, severely damaging three homes, and forcing the evacuation of more than 60 homes. Three firefighters were injured while responding to the fires. The explosion was caused by a contractor who accidentally bored through the gas main and the sewer line.

July 24, 1999 Lake Orion (Oakland County)

On July 24, 1999, a natural gas explosion heavily damaged a house in Lake Orion, but caused no injuries or fatalities. The explosion was believed to be caused by contractors who had accidentally broken a nearby gas main.

January 13, 2000 Madison Heights (Oakland County)

A natural gas explosion destroyed a Madison Heights home on the morning of January 13, 2000, shortly after a utility service person had visited the home to check on a report of a possible natural gas leak. The service person corrected what was believed to be the problem and then left the home. Less than three hours later, the home was completely destroyed by the blast. No one was home at the time of the explosion and no injuries were reported.

February 11, 2000 Detroit (Wayne County)

A natural gas explosion at a Detroit home on February 11, 2000 blew out one wall and scattered bricks onto a neighboring home. No one was home at the time of the explosion and no injuries were reported.

June 7, 2000 Jackson County

On the morning of June 7, 2000, a Wolverine Pipeline Company gasoline pipeline ruptured in Jackson County's Blackman Township, releasing 75,000 gallons of gasoline into the environment and forcing the evacuation of more than 500 homes in a one square mile area around the spill. The leak was detected when a drop in pressure was recorded at a metering station along the 80-mile pipeline that runs through Blackman Township from Joliet, Illinois to Detroit. The spill caused significant environmental and public safety problems and shut down 30% of the state's gasoline supplies for nine days. (The pipeline carries approximately seven million gallons of gasoline per day.) Most of the evacuees were allowed to return to their homes within five days of the accident. Wolverine Pipeline Company worked with affected federal, state, and local regulatory agencies to develop and implement a plan to complete the pipeline repair, cleanup and restore contaminated sites, and provide for long term environmental monitoring. Wolverine Pipeline Company expended in excess of $10 million in response to this pipeline accident.

August 7, 2000 Canton Township (Wayne County)

A Canton Township home was destroyed in an August 7, 2000 natural gas explosion caused by a broken pipe that fed natural gas to the furnace. Two homeowners were hospitalized for injuries sustained in the blast, which also caused significant fire damage to two neighboring homes.

August 8, 2000 Redford Township (Wayne County)

On August 8, 2000, a Redford Township couple was killed and their home destroyed by a natural gas explosion, caused by a broken connection leading to the kitchen range.

September 7, 2000 St. Clair (St. Clair County)

On September 7, 2000, a propane explosion destroyed a house in downtown St. Clair and killed an elderly occupant and a repairman who was working on the house. A second repairman was thrown across the street by the explosion, and sustained injuries. The explosion damaged neighboring homes, but no other injuries were reported.

October 21, 2000 Woodland Park (Newaygo County)

A propane explosion on October 21, 2000, demolished a summer home in Woodland Park and killed 4 members of a family, just minutes after they had arrived at the home for a weekend visit. Two other family members survived the blast, which may have originated in the basement of the home.

March 18, 2001 Warren (Macomb County)

An apparent natural gas explosion destroyed a portion of a plastics factory in Warren on March 18, 2001. Fortunately, the building was empty at the time of the explosion, which collapsed the roof and blew out parts of the wall at the loading dock, causing significant damage.

December 18, 2001 Waterford (Oakland County)

An apparent natural gas explosion destroyed a Waterford home on December 18, 2001, and injured two family members. The blast hurled one of the injured persons more than 60 feet across the street.

December 20, 2001 Southfield (Oakland County)

A 12-inch, high-pressure natural gas main ruptured near a commercial strip in Southfield on the evening of December 20, 2001, injuring one person and forcing the evacuation of several businesses in the area. The explosion was apparently caused by a leak in the pipeline.

March 15, 2002 Crystal Falls (Iron County)

On March 15, 2002, a pipeline break occurred in Crystal Falls, resulting in a half hour of rerouted traffic and two months of pipeline shut-down. The cost of repair was around 4 million dollars.

August 31, 2002 Dansville (Ingham County)

An apparent natural gas explosion destroyed an apartment complex on August 31, 2002, killing a woman who was moving into the building and injuring four others. The explosion forced a nearby road to be closed for several days while debris was removed.

September 15, 2002 Bangor Township (Van Buren County)

An apparent natural gas explosion destroyed a farm house and killed five family members. The one-story home was flattened by the blast. Small pieces of debris were scattered up to a quarter-mile away.

November 20, 2002 Rose Township (Oakland County)

An apparent propane leak caused a house in Wayne County to explode. Houses up to 1,000 feet away were shaken as well. Amazingly, the man in the destroyed house made it out alive, with only a few cuts on his forehead.

September 20, 2003 Detroit (Wayne County)

A natural gas explosion destroyed three houses and caused minor damage to nearly 10 others. The explosion at a vacant house resulted in fires that destroyed occupied homes on both sides of it. Residents escaped with only minor injuries. Cars parked on the street nearby were also destroyed.

April 14, 2004 Taylor (Wayne County)

A natural gas leak caused a house in Taylor to explode, shooting debris 100 feet in all directions. Remains from the house were discovered in yards five lots away, and houses up to a mile away were shaken by the explosion.

September 3, 2005 Caledonia Township (Shiawassee County)

Over Labor Day weekend in 2005, a Shiawassee County home exploded while relatives were gathered for a family reunion. A total of six children were killed, and three more were seriously injured from the blast. Witnesses claimed that they felt the blast up to 10 miles away. Analysis showed that there was something wrong with the copper tubing that had carried propane gas to the Copas Road home. It was reported that the copper tubing was too thin and that proper tests had not made certain that the tubing wouldn't leak. Large amounts of liquid propane seeped into the ground, gas filled the basement, and the smallest spark could therefore trigger the blast.

December 12, 2006 Mason Township (Cass County)

On December 12, 2006 a natural gas pipeline explosion occurred at US-12 and Tharp Lake Road in Mason Twp. Homes within a half mile of the incident were evacuated, and traffic was also diverted. The explosion had occurred when a Midwest Energy employee was operating a trencher and struck the pipeline, resulting in one fatality.

July 17, 2007 Mayville (Tuscola County)

A man was trying to light his home's propane-fueled water heater when an apparent gas leak caused an explosion. The man was sent to the hospital in critical condition. Firefighters didn't have much of a fire to battle because the explosion was one big flash. The house collapsed in on itself and required demolition.

August 28, 2007 Muskegon (Muskegon County)

A house exploded after a contractor accidentally struck a natural gas line. Fortunately, no one was inside the home when the incident occurred. The explosion also caused damage to a neighbor's house.

November 20, 2007 Canton Township (Wayne County)

Natural gas leaks at 8am on November 20, 2007 led to a house exploding in Canton Township. One woman was injured and was pulled from the rubble by neighbors.

February 26, 2008 Grand Rapids (Kent County)

A natural gas explosion occurring at 3:30pm on February 26, 2008 resulted in the collapse of a two story building. Seven persons were injured, and five neighboring businesses suffered damage. A fire burned well into the night, due to an inability to shut off the natural gas until 9:30pm because the fire wouldn't allow access. Three quarters of the city's firefighters were involved in the effort, with neighboring departments covering calls in the city. A gas leak was also detected under the road.

February 28, 2008 Flint (Shiawassee County)

Around noon on February 28, 2008, a man was injured in a house explosion that was an apparent suicide attempt. The man disconnected a gas line in his house and then intentionally sparked the blast, resulting in the explosion of his Linden Place manufactured home. The park's maintenance manager kicked in the door to the home and pulled the man to safety just before a major fire broke out, and fire fighters later rescued a pet cat safely.

March 29, 2008 Lake Ann (Benzie County)

A man was injured as a result of a propane explosion that destroyed a house. Debris was sent flying more than 1,600 feet, and the explosion and fire had been triggered by a relief valve blocked by snow falling off the house's roof.

June 25, 2008 Yankee Springs (Barry County)

One person died during an overnight fire in a lake house at Gun Lake, followed by an explosion caused by a gas line rupture which then took place.

July 14, 2008 Allegan (Allegan County)

On July 14, 2008 a two story house exploded during the night in Lee Township. Nobody was injured because no one was home at the time of the incident.

August 6, 2008 Hastings (Barry County)

A house explosion near Hastings blew out the home's windows and caused severe structural damage. Two teenage boys were inside the home but managed to leave without injury. An investigation found that the explosion was a result of a build-up of leaking propane gas that ignited in the home's basement. The explosion did not cause a fire but the explosion blew the house about 6 inches off of its foundation.

December 5, 2008 Colon (St Joseph County)

A man was killed in a one-car crash that ruptured a gasoline pipeline valve and caused a massive explosion and fire in St Joseph County. The pipeline, which spilled 14,322 gallons of oil, was shut down for more than a week, and authorities routed traffic around the area as the fire continued to burn out.

December 13, 2008 Maple Grove (Saginaw County)

A natural gas leak caused an explosion and fire that burned down a Saginaw County home. Two residents escaped without injury. Freezing winds, icy conditions, poor accessibility, and a lack of water made it difficult for neighborhood fire fighters to stop the blaze. The gas was shut off at the meter and a 3,000 gallon tanker was sent in to help eliminate the hazard.

August 4, 2009 Clio (Genesee County)

In the afternoon of August 4, 2009, an employee reported a small fire at an electrical meter outside one of the buildings at the White Oil Co. Storage Facility plant in Clio when a massive fire broke out and shot heavy plumes of black smoke into the air. Several 50 gallon oil barrels created explosions over 50 feet in the air. Twenty-five fire departments responded, sending over 100 fire fighters to battle the blaze. There were no reported major injuries, and only two minor injuries, but emergency officials contacted about 4,000 residential and business telephone numbers to notify them of the evacuation within a 2 mile radius. Around 150 people were sent to a shelter, and motorists were asked to avoid the area as well.

September 17, 2009 St. Clair Shores (Macomb County)

A gas leak was the reason for a home to explode in St. Clair Shores that resulted in the death (the following day) of the home's 83-year-old owner.

October 2, 2009 Tallmadge Township (Ottawa County)

A natural gas buildup in the afternoon of October 2, 2009 was the cause of a rental house explosion in Ottawa County. Nobody was injured at the time because the previous tenant had moved out the day before, but the debris also destroyed the neighboring houses' windows.

May 16, 2010 Kentwood (Kent County)

A natural gas leak caused a four-unit apartment to explode on May 16, 2010, resulting in 4 injuries. The gas leak occurred in a vacant apartment in the complex. The scene resembled that of a tornado, with debris scattered nearby, shards of broken window glass littered on the ground, lumber lodged into a neighbor's garage, and siding propelled through a neighbor's window.

May 29, 2010 Constantine (St Joseph County)

On May 29, 2010 a gasoline pipeline rupture spilled 89,000 gallons of fuel on farmland west of Constantine. The underground leak sprayed a two- to three-foot-high plume of gasoline into the air and saturated the ground of a newly planted corn field. BP Oil, the owner of the 12-inch gasoline distribution pipeline, drilled 70 temporary monitoring wells and set up 40 water extraction points, in an effort to keep the spilled fuel from contaminating groundwater in the areas in southern St. Joseph County. Thousands of gallons of contaminated water were "vacuumed" daily from underground aquifers. No injuries were reported, but 12 people from four nearby homes were evacuated from the area for nearly 48 hours.

June 21, 2010 Oshtemo Township (Kalamazoo County)

A natural gas leak caused an explosion that destroyed a house near Kalamazoo. Fortunately, there were no injuries because the owner of the home was at work and his wife and kids were out of town.

July 2, 2010 Wixom (Oakland County)

A natural gas line leak caused an explosion that destroyed 22 units in an apartment complex. Only one person was injured.

July 21, 2010 Ravenna (Muskegon County)

A man was killed in a propane leak explosion that destroyed his mobile home. The man had attempted to convert a kitchen stove from natural gas to propane, but a leak later occurred, resulting in the explosion while he was sleeping.

July 26, 2010 Calhoun & Kalamazoo Counties Enbridge Pipeline Disaster

On July 26, 2010, an oil spill was discovered by the owners of an oil pipeline, Enbridge Energy Partners L.P., during a maintenance activity at a pumping station located on the south edge of the City of Marshall. The 30-inch pipeline normally transported 190,000 barrels per day from Griffith, Indiana, to Sarnia, Ontario, and passes through Calhoun County and several other Michigan counties. Oil from the pipeline leaked into the Talmadge Creek and then into the Kalamazoo River and began to flow downstream toward Lake Michigan. Enbridge Energy officials shut down the pipeline pumps and closed valves located upstream and downstream from the leak site to stem the flow of additional oil and try to contain the spill. Based on company estimates, up to 19,500 barrels of crude oil had leaked from the pipeline (approximately 800,000 gallons).

Calhoun County declared a local state of emergency and several downstream communities, including Kalamazoo County, took emergency response actions in coordination with Calhoun County. The State Emergency Operations Center in Lansing was activated and a number of state departments and support organizations convened there to monitor the incident and coordinate state response activities with involved governmental agencies and company officials. Representatives of the U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, National Transportation Safety Board, U.S. Department of Transportation and other federal agencies quickly convened at the incident site and began working with company, local and state officials (under a Unified Command structure) to develop and implement a spill containment, recovery, and clean-up plan and protection strategy for the environment and affected local residents.

A coordination facility was established in the City of Marshall and contractors where brought in for environmental restoration and product recovery. Aggressive product recovery efforts were instituted to expedite oil containment and environmental clean-up. Wildlife rescue and rehabilitation operations were also implemented to aid in protecting animals and aquatic life from harm, and saving wildlife that had been adversely impacted by the spill. Health

advisories were issued to protect the public from harm, and some of the nearby residents were evacuated for a time until the air quality improved within the area. A number of contracted cleanup crews were brought in to perform clean-up and product recovery work.
On September 27, the repaired oil pipeline was restarted by company officials, with the approval of the U.S. Department of Transportation. New oil again flowed through the pipeline, initially at a reduced pressure level but then at full capacity again. The unified command center remained operational for an extended period of time, due to the long-term nature of product recovery and environmental clean-up operations. Clean-up and product recovery efforts are still ongoing in 2014, with more than 1.5 million gallons of water treated and huge quantities of material processed off-site to remove and recover the oil.

December 29, 2010 Wayne (Wayne County)

An aging natural gas pipeline exploded under a furniture store, destroying the building and resulting in two fatalities and one injury. Rescue workers spent all day and into the night combing through the pile of crumpled drywall, twisted metal, and broken bits of furniture. The explosion also shattered windows at nearby businesses and hospitalized one person who had been driving by when the building exploded. Police evacuated homes and businesses near the store, and a local state of emergency was declared. Residents in the area had reported the smell of gas to the utility company three hours before the explosion. A second leak was discovered in the same area after the explosion, but was successfully capped before exploding.

January 10, 2011 Grand Rapids (Kent County)

A house exploded as a result of a natural gas leak, causing one fatality and leaving another person critically injured.

January 12, 2011 Columbus (St. Clair County)

One person was hurt during a natural gas explosion at a facility in Columbus. Residents within a five-mile radius of the gas storage company said they first heard a loud boom and then saw a fireball. The company sells natural gas, and stores it in a two-mile-long cavern underground. The explosion occurred during a separation of gas and oil, and then the facility's safety valve kicked in, preventing the fire from spreading until it burned out.

April 13, 2011 White Oak Township (Ingham County)

A gas leak occurred on April 13, 2011 when between 294,000 and 462,000 gallons of gasoline leaked from a faulty Marathon Pipe Line LLC pipeline in mid-Michigan. Marathon originally estimated that 126,000 gallons had leaked into the soil before it was detected by a man in Ingham County's White Oak Township whose 16-acre farm backs up to four fuel storage tanks. Environmental experts said the Ingham County gasoline leak didn't harm residents' drinking water. They also said it was unlikely that contamination from the leak had affected the Red Cedar River watershed and neighboring communities.

May 4, 2011 Warren (Macomb County)

A natural gas explosion in a commercial Laundromat in Detroit's northern suburbs leveled the building and injured two passers-by. The blast was felt several miles away and nearby residents reported seeing a large cloud of smoke.

February 27, 2013 Royal Oak (Oakland County)

A natural gas leak caused an explosion that killed a man and destroyed three homes. The explosion also resulted in the evacuation of two streets in the neighborhood for multiple days. The utility company was fined $340,000 by the Michigan Public Service Commission, since their work crew was aware of the leak but left the scene prior to the blast. Multiple employees related to the incident were also terminated. In addition to the fines, the utility company will give $1 million to a new fund that will help victims of natural gas disasters and fund improved training and safety practices for utility workers.

The relatively small number of deaths and injuries associated with these petroleum and natural gas pipeline accidents is a testament to the emergency preparedness efforts of the pipeline companies and local communities, as well as the regulatory oversight of the Michigan Public Service Commission and the U.S. Department of Transportation's Office of Pipeline Safety. The possibility is always there for a significant accident to occur, since Michigan is crisscrossed by several major petroleum and natural gas pipelines. Pipelines could rupture at any time, resulting in severe explosion, fire, property damage, environmental contamination, and casualties.

Programs and Initiatives

Pipeline jurisdiction and oversight in Michigan is complex, determined primarily by the type and function of a pipeline and its location. Agencies involved include (1) the MPSC Gas Safety Office, (2) the USDOT/OPS in Kansas City, Missouri, and (3) the Michigan Department of Environmental Quality, Office of Geological Survey (MDEQ/OGS). The table below is a breakdown of jurisdictional and inspection responsibilities for the various types of pipelines present in Michigan:

Pipeline Safety Regulation in Michigan

Pipeline Type	Jurisdiction	Applicable Code	Inspected By
Inter-state Natural Gas	USDOT/OPS	49 CFR Part 192	MPSC Gas Safety
Intra-state Natural Gas	State of Michigan/MPSC	Michigan Gas Safety Standards	MPSC Gas Safety
Liquid Petroleum	USDOT/OPS	49 CFR Parts 193/195	USDOT/OPS
Gathering Lines*	MDEQ/OGS	Oil/Gas Administrative Rules under Part 615, 1994 PA 451	MDEQ/OGS

*Note: Gathering lines run from a production facility (i.e., a well) to a pre-processing plant (i.e., dehydration facility, or separator, compression station).
Source: Michigan Public Service Commission, Gas Safety Office.

The issue of gathering line jurisdiction is even more complex. Gathering lines in non-rural areas fall under the jurisdiction of the Michigan Gas Safety Standards. Gathering lines that serve as common carriers fall under the

jurisdiction of the MPSC, but may not necessarily fall under the Michigan Gas Safety Standards. All other gathering lines fall under the jurisdiction of the MDEQ/GSD. (Note: Even though gathering lines in rural areas do not fall under the direct jurisdiction of the Michigan Gas Safety Standards, the MPSC requires all common carrier pipelines to be designed, constructed and operated under the requirements of the Standard.)

The following are major programs and initiatives in place to help ensure petroleum and natural gas pipeline safety in Michigan.

Michigan Gas Safety Standards

Pipeline operators are regulated under the Michigan Gas Safety Code, 1969 PA 165 and its implementing Administrative Rules - the Michigan Gas Safety Standards, to ensure that public safety is protected to the extent that is possible in the industry. Under the Code (which is administered by the MPSC), gas pipeline companies (operators) must develop and maintain written procedures to minimize the hazards resulting from a gas pipeline emergency. The procedures must provide for the following: 1) identification and classification of events; 2) notification of and communication with local response agencies and public officials; 3) response to all types of gas emergencies, including emergency shutdown and pressure reduction procedures; 4) coordination of response actions with the local jurisdiction(s); and 5) restoration of service. Operators must also ensure that personnel are properly trained and knowledgeable about emergency procedures. If an incident occurs, the operator must review response actions to determine whether procedures were followed, and if necessary, take samples of the failed facility or equipment for laboratory examination to determine the cause of the failure. Mitigation actions are taken as necessary to minimize the possibility of a recurrence. The latest edition of the Michigan Gas Safety Standards was filed with the Secretary of State and became effective on April 17, 2009.

Consumers Energy has stated that it will give $1 million to a new fund that will help victims of natural gas disasters and fund improved training and safety practices for utility workers.

U.S. Department of Transportation, Office of Pipeline Safety

Additional pipeline safety requirements are contained in the Federal Safety Standards (Parts 191, 192, 193 and 195), as administered by the USDOT/OPS. Interstate gas and liquid petroleum pipeline operators must develop and maintain written emergency procedures similar to those required under the Michigan Gas Safety Standards. In addition, they are required to coordinate both planned and actual response actions with local officials and response agencies. There is also a Federal Grant Program authorized to reimburse a state agency up to 80 percent of the actual cost for carrying out its pipeline safety program. The actual amount of Federal reimbursement depends upon the availability of appropriated funds and state program performance (and the formula used to allocate funds includes performance factors). The Natural Gas Grant Allocation and Hazardous Liquid Grant Allocation participate in the program. The OPS provides grant funding to Michigan to improve communication among excavators and owners of underground facilities. The PIPES Act of 2006 also authorizes grants to Michigan state authorities, designated by the Governor, to create or maintain effective State damage prevention programs.

Part 195 also has a continuing education requirement to keep local officials and the general public informed about the risks associated with the transportation of hazardous liquids via pipeline. OPS and Michigan partners regularly participate in joint government-industry-public committees and task forces to discuss and address concerns related to risk management, compliance, emerging technology, damage prevention, and environmental protection. Current initiatives include the Risk Management Demonstration Program, the Local Distribution Company Feasibility Study, Technical Pipeline Safety Standards Committees, Best Practices for One-Call Centers, and the National Pipeline Mapping System (GIS-based).

MPSC Pipeline Safety Inspections

MPSC safety engineers are certified by the USDOT/OPS to conduct inspections on natural gas pipelines to ensure the structural and operational integrity of the systems. If violations are found, the pipeline company can be

ordered to take corrective actions, and the pipeline operator may be fined. The MPSC safety engineers also respond to accidents involving natural gas or petroleum pipelines (to ensure compliance with federal and state law, and to offer technical assistance to emergency responders).

The Protection of Underground Facilities Act / MISS DIG Program

Michigan's first line of defense against pipeline (and other utility line) breaks from construction excavations is the "MISS DIG" Program established with the passage of 1974 PA 53 – The Protection of Underground Facilities. MISS DIG System, Inc., is a 24-hour utility communications system that helps contractors comply with the state law (Act 53) that requires the notification of utilities at least three working (but not more than 21 calendar) days before starting the excavation, tunneling, demolishing, drilling or boring procedures, or explosive discharges for a project. When properly administered and followed, the MISS DIG safety system does an excellent job of minimizing pipeline and utility line accidents.

National Transportation Safety Board

The National Transportation Safety Board (NTSB) investigates all significant pipeline accidents in the U.S., and provides pipeline company and government regulators with safety recommendations aimed at preventing future accidents. The NTSB also publishes a list of "most wanted" safety improvements, for pipelines and other modes of transportation, for nationwide implementation by appropriate entities. Although these safety improvement recommendations are not mandatory, and the NTSB has no regulatory or enforcement powers, it nonetheless has been successful in getting more than 80% of its recommendations adopted. Many safety features currently incorporated into pipelines and other transportation modes had their genesis in NTSB recommendations.

Local Emergency Capability

Communities that may be affected by petroleum or natural gas emergencies should have adequate procedures in their Emergency Operations Plans to address the special types of problems associated with this hazard, including specific functions such as rescue and evacuation. Affected communities must work closely with company officials and surrounding jurisdictions to ensure a fast, coordinated response. Mitigation possibilities include the use of community zoning regulations to provide suitable open, unoccupied "buffer" areas around pipelines, storage fields, refineries, and compressor stations.

American Petroleum Institute (API) Recommended Practice (RP) 1162

The American Petroleum Institute (API) Recommended Practice (RP) 1162, "Public Awareness Programs for Pipeline Operators" has regulations for pipeline operators to provide the affected public with information about how to recognize, respond to, and report pipeline emergencies. The importance of using the one-call notification system prior to excavation is to be emphasized for all stakeholders. Emergency officials and local public officials must be provided with information about the location of transmission pipelines, to enhance emergency response and community growth planning. Affected municipalities, school districts, businesses, and residents must be advised of pipeline locations. Of particular significance is the requirement that operators must periodically review their programs for effectiveness, and enhance the programs as necessary.

This industry consensus standard provides guidance and recommendations to pipeline operators for the development and implementation of enhanced public awareness programs. It addresses multiple elements of such programs, including the intended audiences, the kinds of information to be communicated, frequencies and methods of communicating the information, and evaluation of the programs' effectiveness.

Michigan Propane Gas Association (MPGA)

The Michigan Propane Gas Association was created to promote the proper handling and use of propane, to work for a favorable environment for propane distribution and marketing, and to increase its use by demonstrating propane's value as a clean energy source. The MPGA is a trade and membership service organization that represents propane marketers throughout the state. The MPGA's primary purpose is to maintain high standards of

practice within the industry and, in so doing, protect and expand the ability of its members to compete in the marketplace.

Interstate Natural Gas Association of America (INGAA)

The Interstate Natural Gas Association of America (INGAA) is a trade organization that advocates regulatory and legislative positions of importance to the natural gas pipeline industry in North America. Its members transport over 95 percent of the nation's natural gas through a network of 200,000 miles of pipelines. The interstate natural gas pipeline industry has two principal federal regulators: the Federal Energy Regulatory Commission (FERC) is responsible for the economic regulation of pipelines, while the U.S. Department of Transportation (DOT) Office of Pipeline Safety oversees the industry's safety efforts. INGAA's primary mission is to create a regulatory and legislative climate that allows interstate natural gas pipeline companies to optimize efficient and profitable operations.

Nonprofit Pipeline Safety Organizations

There are several nonprofit organizations and agencies that provide information encouraging pipeline safety in Michigan. These organizations can work to educate the public by organizing meetings, seminars, and workshops to improve pipeline reliability, operational efficiency, and the regulatory environment. These organizations can support the safe delivery of pipeline products; research pipeline operational problems; act as a common ground forum where members can discuss and seek solutions to industry problems; promote underground facilities, damage prevention, and implementation of damage prevention best-practices to all stakeholders; and represent industry interests before Congress, federal agencies, and other energy-related stakeholders by developing regulatory and legislative policies. These particular organizations include the National Association of Pipeline Safety Representatives (NAPSR), Association of Oil Pipe Lines (AOPL), American Public Gas Association (APGA), Pipeline Research Council International, Inc. (PRCI), the Common Ground Alliance (CGA), etc.

Analysis and Impact

The map at the end of this section shows the location of major petroleum and natural gas pipelines within Michigan. It is apparent from the map that petroleum and natural gas pipelines crisscross the entire state, from well heads to storage sites to distribution to consumers. Major compressor stations that receive and redistribute natural gas are located at key points along the pipelines (but are not shown on the map). These stations monitor and maintain pressure levels within the pipelines. In the event of a pipeline rupture, the compressor stations shut down to stop the flow of product. Many smaller compressor stations are located across the state to complete the distribution process to consumers.

The state's major natural gas storage facilities are located in the central part of the Lower Peninsula. Natural gas is piped into those storage facilities from Michigan wells, and from large transmission pipelines that originate in Canada, the southwestern United States, and the Gulf of Mexico area.

Petroleum pipelines carrying crude oil, fuel oil, propane, butane, gasoline and other petroleum products have their heaviest concentrations in central Lower Michigan and between Detroit and Toledo. Many of the refineries, terminals, and storage areas are located in urban areas where the potential for extensive damage, and threat to lives and property, is greatest. The largest concentration of these facilities is found in the Detroit metropolitan area.

Petroleum and natural gas pipeline accidents are on the rise, due to the aging of the underground infrastructure (much of which was laid over 50 years ago) and an increase in construction excavation. According to studies conducted by the General Accounting Office (GAO), an average of 22 people died annually from 1988 to 1998 when the number of accidents was increasing four percent per year. The GAO also found that the USDOT/OPS has not adequately enforced many safety regulations passed by Congress since 1988 and is instead relying more on industry self-regulation as an enforcement tool.

Increased pipeline safety regulations again came to the forefront in 2000 after deadly pipeline explosions occurred in Bellingham, Washington in June 1999 (three deaths) and Carlsbad, New Mexico in August 2000 (11 deaths). In 2004, the Pipeline and Hazardous Materials Safety Administration (PHMSA) was signed into law. The purpose of the Act was to provide a more focused research organization and establish a separate operating administration for pipeline safety and hazardous materials transportation safety operations.

The Pipeline Safety Improvement Act of 2002 mandated significant changes and new requirements in the way that the natural gas industry ensures the safety and integrity of its pipelines. The law applies to natural gas transmission pipeline companies. The law places requirements on each pipeline operator to prepare and implement an "integrity management program" that, among other things, requires operators to identify so-called "high consequence areas" (HCA) on their systems, conduct a risk analysis of these areas, perform baseline integrity assessments of each pipeline segment, and inspect the entire pipeline system. Companies were required to identify all HCAs and submit specific integrity management programs to the Office of Pipeline Safety (OPS), the Research and Special Projects Administration, and the U.S. Department of Transportation. All pipeline segments within HCAs were to be inspected and remediation plans completed by December 17, 2008, while non-HCA segments must be inspected by 2012. All segments must be re-inspected on a 7-year cycle, with certain exceptions.

Because petroleum and natural gas pipeline accidents will occur eventually, affected local communities must be prepared to respond to the accident, institute necessary protective actions, and coordinate with federal and state officials and the pipeline company emergency crews to effectively manage and recover from the accident. That can best be accomplished through the collaborative planning, training, and exercising of emergency procedures with all potentially involved parties.

Hazard Mitigation Alternatives for Pipeline Accidents

- Locating pipelines away from dense development, critical facilities, special needs populations, and environmentally vulnerable areas whenever possible.
- Increasing public awareness and widespread use of the "MISS DIG" utility damage prevention service (800-482-7171).
- Proper pipeline design, construction, maintenance and inspection.

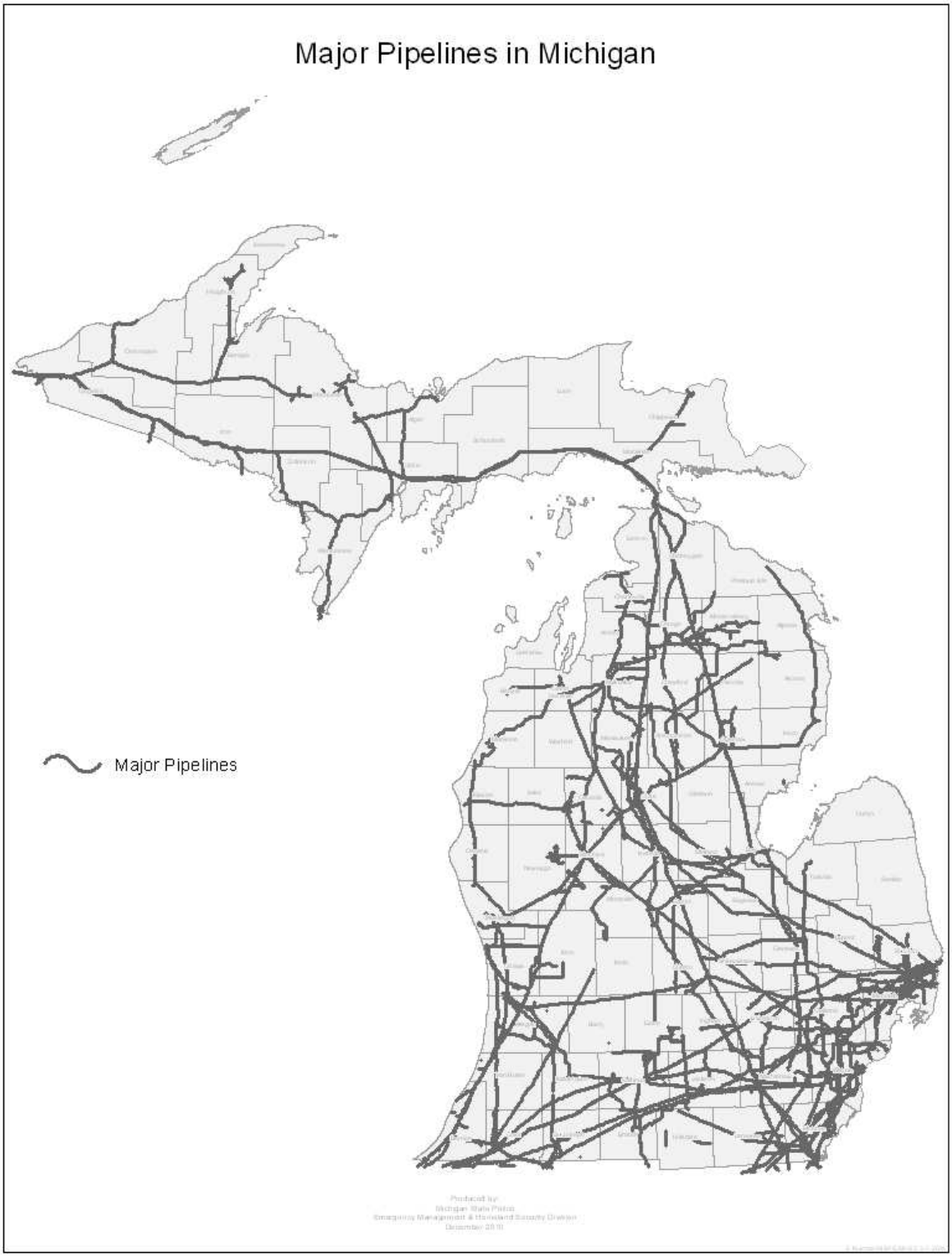
Tie-in with Local Hazard Mitigation Planning

Because many means of implementing mitigation actions occur through local activities, this updated MHMP places additional emphasis on the coordination of State-level planning and initiatives with those taking place at the local level. This takes two forms:

1. The provision of guidance, encouragement, and incentives to local governments by the State, to promote local plan development, and
2. The consideration of information contained in local hazard mitigation plans when developing State plans and mitigation priorities.

Regarding the first type of State-local planning coordination, MSP guidance has included the "Local Hazard Mitigation Planning Workbook" (EMD-PUB 207), which is currently being updated for release by 2015. For the second type of State-local planning coordination, a section later in this plan summarizes hazard priority information as it has been reported in local hazard mitigation plans. Here, it will merely be noted that pipeline accidents were considered to be a significant hazard in the local hazard mitigation plan for St. Clair County.

Major Petroleum and Natural Gas Pipelines in Michigan
Source: Michigan Public Service Commission; pipeline company maps



OIL AND NATURAL GAS WELL ACCIDENTS

An uncontrolled release of oil or natural gas, or the poisonous by-product hydrogen sulfide, from production wells.

Hazard Description

Oil and natural gas are produced from fields scattered across 63 counties in the Lower Peninsula. From 1927 to January 2009, there have been 56,525 oil and natural gas wells drilled in Michigan, of which roughly half have produced oil and gas. To date, Michigan wells have produced over 1.4 billion barrels of crude oil and 6 trillion cubic feet of gas.

The petroleum and natural gas industry is highly regulated and has a fine safety record, but the threat of accidental releases, fires and explosions still exists. In addition to these hazards, many of Michigan's oil and gas wells contain extremely poisonous hydrogen sulfide (H_2S) gas. Hydrogen sulfide is a naturally occurring gas mixed with natural gas or dissolved in the oil or brine and released upon exposure to atmospheric conditions. Over 1,300 wells in Michigan have been identified as having H_2S levels exceeding 300 parts per million (ppm).

As the table below indicates, at concentrations of 700 ppm, as little as one breath of hydrogen sulfide can kill. Although hydrogen sulfide can be detected by a "rotten egg" odor in concentrations from .03 ppm to 150 ppm, larger concentrations paralyze a person's olfactory nerves so that odor is no longer an indicator of the hazard. Within humans, small concentrations can cause coughing, nausea, severe headaches, irritation of mucous membranes, vertigo, and loss of consciousness. Hydrogen sulfide forms explosive mixtures with air at temperatures of 500 degrees Fahrenheit or above, and is dangerously reactive with powerful oxidizing materials. Hydrogen sulfide can also cause the failure of high-strength steels and other metals. This requires that all company and government responders be familiar not only with emergency procedures for the well site, but also with the kinds of materials that are safe for use in sour gas well response.

Physiological Response to H_2S

10 ppm	Beginning eye irritation
50-100 ppm	Slight conjunctivitis and respiratory tract irritation after 1 hour exposure
100 ppm	Coughing, eye irritation, loss of sense of smell after 2-15 minutes. Altered respiration, pain in the eyes and drowsiness after 15-30 minutes, followed by throat irritation after 1 hour. Several hours of exposure results in gradual increase in severity of these symptoms and death may occur within the next 48 hours.
200-300 ppm	Marked conjunctivitis and respiratory tract irritation after 1 hour of exposure.
500-700 ppm	**Loss of consciousness and possibly death in 30 minutes to 1 hour.**
700-1000 ppm	**Rapid unconsciousness, cessation of respiration, and death.**
1000-2000 ppm	**Immediate unconsciousness, with early cessation of respiration and death following within a few minutes. Death may occur even if the individual is removed to fresh air at once.**

Source: American National Standards Institute, Standard: 237.2-1972

An unplugged abandoned well, also known as an orphan well, can be a hazard to the health and safety of the surrounding people and environment. There are many situations where an unplugged well can become dangerous. For example, a rusted-out casing in a gas well can let natural gas flow underground and accumulate in the basement of a nearby building, possibly causing an explosion. Occasionally, gas leaking from an old well can contaminate a nearby water well. An old well might also be a conduit for salt brine from deeper formations to pollute fresh groundwater, or to discharge at the surface. In some cases, oil leaks from abandoned wells, polluting soil and water. In the vicinity of a coal mine, an old well can be a conduit for explosive gas to enter the mine, a

serious mine safety problem. Also, where coal mining has occurred, an old well can allow acidic mine water to discharge at the surface.

Hazard Analysis

Over the years, Michigan has experienced periodic upward and downward trends in oil and natural gas production as new reservoirs were discovered and older ones became depleted. However, oil production has been declining at 5-8% per year since 1990. Natural gas production peaked in 1998 and has also begun to indicate a decline in production. As the table and map indicate at the end of this section, a large number of Michigan's oil and natural gas wells are located in the western counties bordering on Lake Michigan, and in the central part of the Lower Peninsula. A thin band of fields also runs from Calhoun County to St. Clair County in the southern Lower Peninsula, and across the northern Lower Peninsula from Manistee County to Presque Isle County. Oil and natural gas wells are scattered around other Lower Peninsula counties, but the Upper Peninsula contains few productive oil and gas wells.

Michigan reaps tremendous economic and social benefits from oil and natural gas production. As with all industrial and commercial activities, along with those benefits come some risks as well. Despite the best efforts of the MDEQ Office of Geological Survey and the drilling companies to minimize oil and natural gas well accidents, it is inevitable that such accidents will occur from time to time. When they do, the affected local communities must be prepared to respond to the accident, institute necessary protective actions, and coordinate with state officials and drilling company emergency crews to effectively manage and recover from the accident. That can best be accomplished through collaborative planning, training, and the exercising of emergency procedures with all potentially involved parties.

Using revenues from oil and gas production taxes, the Michigan Department of Environmental Quality has plugged and restored at least 200 wells. Out of the 62,376 oil and gas wells drilled in Michigan since the 1920s, 26 orphan wells remain to be plugged as of 2012.

It can be difficult to accurately assess incident probabilities for oil and gas wells, but some indications might be gained from existing OSHA data. As related in the section on hazard identification, information about the location of wells is available since permits needed to be issued before they are dug or drilled. If permit sites are near developed or potentially sensitive areas, specific inquiries can then be made with MDEQ to see if the permit actually resulted in a well being created, whether the well is still open or has been capped, and whether open wells have been known to contain hydrogen sulfide. Wells that are open and potentially hazardous should be reconsidered if they are located very near to vulnerable populations or densely developed areas.

More than one agency has requested that this plan include more specific information about any risks associated with hydraulic fracturing methods of extraction (also known as “fracking”). Concerns have been expressed about reports of water and air pollution in other states, but the situation in Michigan can be seen to differ in more than one way. Michigan has a history of hydraulic fracturing that dates back to 1952, involving more than 12,000 wells without any resultant environmental damage. Michigan has many impermeable formations in its bedrock, which provide extensive separation between these wells and the location of groundwater, therefore meaning that groundwater contamination is prevented (unlike the formations in some other states where evidence of such contamination has been detected). These geological conditions and Michigan’s greater regulatory system, combined with a scale of extraction that is much less than several other states (in which problems have been widely publicized), means that there is no reason to consider that this method of extraction poses any greater risk within the state. As with wells that have been dug through other means, the primary sources of risk from any well are the two that have already been identified in previous editions of this plan: (1) the ability of a well to “sour” by producing poisonous hydrogen sulfide gases, and (2) the risk that an accidental explosion may occur. Both of these risks do happen from time to time, but usually do not strongly affect areas outside of the well site itself. Please refer to the list of Michigan events, for more detail about the extent (and limits) of actual and recent historical cases in Michigan. Extraction technology (and safety) has been improving over time.

Impact on the Public
Those who are in or near a well site during a hazardous event (workers, inspectors, trespassers) may face severe injury or death. Those living in the close vicinity of such a well may potentially be affected by gases and thus require temporary evacuation, but these cases would be extremely rare.

Impact on Public Confidence in State Governance
An event of significant size or impact may provoke a perception that inadequate regulation, authorization, or oversight was maintained by the state.

Impact on Responders
Wells may contain poisonous hydrogen sulfide gas, and thus require responders to use special equipment when nearby. Special search and rescue skills may be needed for victim extraction. In this regard, the oil and gas well hazard may be considered to be similar to a fixed site hazardous materials incident (q.v).

Impact on the Environment
The process of getting oil and natural gas from underground to the end user has the potential to be environmentally destructive. The environmental impacts of oil and natural gas well accidents include the emission of air pollutants, leaks and spills, groundwater contamination, and the effects of well "blowouts." Many of Michigan's oil and gas wells contain extremely poisonous hydrogen sulfide (H_2S) gas. Productive natural gas wells and their associated utilities and access roads also "eat up" natural land, and many areas where gas is found are natural areas where drilling puts industrial facilities into rustic settings.

An unplugged abandoned well (orphan well) can be a hazard to the environment. For example, a rusted-out casing in a gas well can let chemical substances flow underground, and gas leaking from an old well could contaminate a nearby water well. An old well might also be a conduit that allows salt brine from deeper formations to pollute fresh groundwater, or to discharge at the surface. In some cases, oil leaks from abandoned wells may cause the pollution of soil and water.

Significant Oil and Natural Gas Well Accidents
To date, Michigan has been fortunate not to have an oil or natural gas well accident that resulted in loss of life (other than to company employees) or caused significant property damage. However, significant oil and natural gas well accidents have occurred that required an emergency response by the drilling company and by state and local officials:

April 1973 Williamsburg (Grand Traverse County)
The drilling of oil and natural gas wells may result in another type of hazard, as demonstrated by an incident near Williamsburg in Grand Traverse County during April 1973. Gas pressure in a well forced gas through porous rock formations to the surface. This eruption of natural gas caused craters of bubbling muddy water that flowed into nearby streams and into the Grand Traverse Bay. Due to the threat of an explosion, the townspeople of Williamsburg were evacuated, but an explosion did not occur. Damage was confined to building foundations (which settled) and environmental damage to trees and streams. Fortunately, the Williamsburg incident was resolved without death or injury. The Michigan Department of Natural Resources subsequently imposed improved well casing and sealing requirements to prevent this type of occurrence.

April 16, 1984 Bay County
On April 16, 1984 a sour gas well in Hampton Township (Bay County) developed a leak at its surface casing, emitting sour gas for several hours. Residents within a half-mile radius were evacuated for approximately 24 hours until the well could be completely repaired. There were no injuries or property damage.

February 24, 1988 Buckley (Wexford County)
On February 24, 1988 a gas leak occurred in a well located near the village of Buckley in Wexford County. Several children in a nearby school complained of nausea from the strong odor, so the school was evacuated as a precaution. After a short investigation, the well site was located and it was determined that the site had suffered a deck blow-off and was emitting gas directly into the atmosphere. The well was subsequently shut down until permanent repairs could be made.

January 9, 1989 Arenac County
On January 9, 1989 a natural gas well blew out in Au Gres Township, Arenac County. Although there was no fire, methane, butane, and hydrogen sulfide leaked from the wellhead. The surrounding area was evacuated while attempts were made to seal the leak with mud and concrete and to replace the wellhead. On January 11, a new valve was successfully installed and the community resumed its normal activities.

February 17, 1989 Grand Traverse County

On February 17, 1989 a Shell Western oil well in Mayfield Township (Grand Traverse County) blew out, resulting in an evacuation of nearby residents and the cancellation of local school classes. The well was eventually capped, later that night.

June 15, 1993 St. Clair County

On June 15, 1993 a natural gas explosion occurred at a Michigan Consolidated Gas Company (MICHCON) underground storage facility in Columbus Township, St. Clair County. One worker was injured in the explosion, two vehicles were burned, and several homes in the immediate vicinity of the facility were evacuated.

February 3, 1994 Ogemaw County

On February 3, 1994 an explosion and fire occurred when a pipe released gas under pressure at an American Oil Company (AMOCO) production facility in Ogemaw County. One service company employee was killed and another employee was injured. The situation was immediately brought under control with no additional injuries, damage, or threat to public safety.

May 13, 1994, and August 1996 Manistee and Mason Counties

An accident occurred when a blown gasket released hydrogen sulfide emissions after a seal in a compressing station in Mason County's Victory Township failed. The incident resulted in 11 people requiring emergency hospital treatment (four of them children) and the death of 10 cattle. Another similar incident occurred two years later when a release of 5,500 cubic feet of natural gas containing 900 ppm of poisonous H_2S occurred in Manistee Township. The release, which occurred while workers were attempting to plug a well, caused several citizens in the neighborhood to lose consciousness and collapse. Eleven victims were treated at the hospital; at least one of them sustained serious lung damage. Others were being treated for symptoms of asthma, skin irritations and neuropsychological problems. From 1980 to 1998, other injuries and evacuations have occurred in Manistee and Mason Counties as a result of H_2S releases. At least 10 separate accidental releases of H_2S from pipelines and processing plants caused at least 262 people in Manistee and Mason Counties to evacuate their homes (five since 1995), caused at least 22 people to have been injured and seek medical treatment since 1994, and caused 35 cattle to be killed in Mason County since 1994. Many more have suffered respiratory and skin complications, and all are bearing the psychological burden of repeated evacuations.

December 2006 Mecosta County

In December, 2006 a gas well burst into an explosion in Mecosta County, resulting in the evacuation of several nearby residents. The issue was later resolved, with no additional threat to public safety.

June 12, 2013 Leoni Township (Jackson County)

An explosion at an oil well placed a man in extremely critical condition and he was airlifted to University of Michigan hospital. Investigators believed that a truck had struck some piping in the oil well, causing an explosion and natural gas fire. The fire was extinguished with foam and water, and did not affect surrounding areas outside of the facility.

Programs and Initiatives

Oil and Natural Gas Well Regulatory Authority

Part 615 of the Natural Resources and Environmental Protection Act, 1994 PA 241, as amended, regulates oil and natural gas well drilling in Michigan. Revisions to this “Supervisor of Wells” statute, in 1999, clarified the Supervisor’s authority to address public health and safety issues. The Administrative Rules for Part 615 were most recently updated in September, 1996. These Rules require the classification of wells using the concept of radius of exposure (RoE). A simple formula is used to calculate the distance, in feet, from the point of release at which the H_2S concentration in air reaches 100 ppm. This is the 100 ppm RoE. Wells with more than 300ppm H_2S in the gas stream are classified according to the 100 ppm RoE. Part 616 deals with an Orphan Well Fund created within the State Treasury for the purpose of plugging the abandoned or improperly closed oil or gas wells, or for response activity, and/or for site restoration at oil or gas wells. The fund can be used when no owner or operator is known, when all owners or operators are insolvent, or when the supervisor determines there is an imminent threat to public health and safety.

Michigan Oil and Gas Association (MOGA)

The Michigan Oil and Gas Association (MOGA) represents the exploration, drilling, production, transportation, processing and storage of crude oil and natural gas in the State of Michigan. The organization has over 1,000 members, which include major oil companies, independent oil companies, and the exploration arms of various utility companies. The MOGA monitors the pulse of the Michigan oil and gas industry as well as the political, regulatory, and legislative interest in the state and the nation's capital as well. The organization has been described as the collective voice of the petroleum industry in Michigan, speaking to the problems and issues facing the various companies involved in the state’s crude oil and natural gas business. One of the ongoing issues of concern to the MOGA is oil and natural gas well safety.

Interstate Oil and Gas Compact Commission (IOGCC)

Michigan is a member of Interstate Oil and Gas Compact Commission (IOGCC) that represents the governors of oil and natural gas producing states. In 1935, six states endorsed and Congress ratified the Interstate Compact to

Conserve Oil and Gas, resulting in the formation of the unique governmental entity now known as the Interstate Oil and Gas Compact Commission. The IOGCC has helped states (including Michigan) to establish effective regulation of the oil and natural gas industry through the gathering and sharing of information, technologies, and regulatory methods. The IOGCC advocates for environmentally sound ways to increase the supply of American energy. This can be accomplished by providing governors of member states with a clear and unified voice to Congress, while also serving as the authority on issues surrounding these vital resources. The unique structure offers a highly effective forum for states, industry, Congress, and the environmental community to share information and viewpoints to advance our nation's energy future. The organization is dedicated to securing resources needed to ensure our nation's energy, economic, and national security.

Michigan Oil & Gas Producers Education Foundation (MOGPEF)

MOGPEF was created in 2003 to assist in supporting educational projects and programs about the industry. It is a tax-exempt organization under Section 501(c) (6) of the United States Internal Revenue Service code. Its mission is to provide financial support for programs that will inform the people of Michigan about the importance of the local oil and natural gas industry and about the environmental safeguards that are employed. Materials and programs developed by MOGPEF are available for use by members of petroleum, energy, and allied industries and by the general public.

Contingency Planning

Contingency plans for public protection are required for wells at which the 100 ppm RoE is greater than 100 feet. The plans are divided into two parts. Part I contains general procedures that must be implemented by company personnel in an emergency when H_2S is released. This includes emergency contacts and their assigned duties and responsibilities, notification and evacuation procedures for the general public, and procedures for igniting the well. Part II contains site-specific information and must be filed with an application for a drilling permit. Well owners have the option of working with the local Emergency Management Coordinator instead of preparing a required site map and list of residences. This option can be used in highly populated areas. Other H_2S Administrative Rules address special equipment requirements for the drilling, testing, and production of H_2S-bearing wells. The Rules are intended to provide for public protection and nuisance odor mitigation.

Local Emergency Capability

Communities that may be affected by oil or natural gas well accidents should have adequate procedures in their Emergency Operations Plans to address the types of problems especially associated with this hazard, including rescue and evacuation. Affected communities must work closely with company officials and surrounding jurisdictions to ensure the compatibility of procedures for a fast and coordinated response. Mitigation possibilities include the use of community zoning regulations to provide suitable open, unoccupied "buffer" areas around refineries and compressor stations. Michigan Department of Environmental Quality regulations provide for buffer zones around wells and around treatment and storage facilities.

Oil and Gas Advisory Committee

The Oil and Gas Advisory Committee advises the MDEQ on matters of regional or state-wide significance relating to oil and gas exploration and production. The Committee provides input on policy, rules, orders, instructions, technical reviews, and hearings. The Committee is composed of members from the oil and gas industry and the public, with background or expertise in oil and natural gas, and related environmental and resource issues.

Michigan Department of Environmental Quality - GeoWebFace online

The Michigan Department of Environmental Quality now provides many GIS layers, along with an online interface called GeoWebFace, which allows users to view oil and gas well information in an interactive map. Its web address is http://ww2.deq.state.mi.us/GeoWebFace/.

Hazard Mitigation Alternatives for Oil and Natural Gas Well Accidents

- Using buffer strips to segregate wells, storage tanks, and other production facilities from transportation routes and adjacent land uses, in accordance with state regulations, and consistent with the level of risk.
- Adherence to all regulations and best industry practices, especially for relatively new techniques of hydraulic fracturing, in order to preserve Michigan's environmental quality and public confidence in the industry.

Tie-in with Local Hazard Mitigation Planning

Because many means of implementing mitigation actions occur through local activities, this updated MHMP places additional emphasis on the coordination of State-level planning and initiatives with those taking place at the local level. This takes two forms:

1. The provision of guidance, encouragement, and incentives to local governments by the State, to promote local plan development, and
2. The consideration of information contained in local hazard mitigation plans when developing State plans and mitigation priorities.

Regarding the first type of State-local planning coordination, MSP guidance has included the "Local Hazard Mitigation Planning Workbook" (EMD-PUB 207), which is currently being updated for release by 2015. For the second type of State-local planning coordination, a section later in this plan summarizes hazard priority information as it has been reported in local hazard mitigation plans. Here, it will merely be noted that the oil and gas well hazard has not yet been identified as one of the most significant hazards in any of Michigan's local hazard mitigation plans.

Michigan's Oil and Gas Wells, by County
(As of 2012)

County	Wells	County	Wells	County	Wells
Alcona	**478**	Gratiot	**1**	Missaukee	**164**
Alger	**0**	Hillsdale	**29**	Monroe	**2**
Allegan	**196**	Houghton	**0**	Montcalm	**32**
Alpena	**894**	Huron	**2**	Montmorency	**2,539**
Antrim	**1,706**	Ingham	**31**	Muskegon	**15**
Arenac	**241**	Ionia	**0**	Newaygo	**33**
Baraga	**0**	Iosco	**7**	Oakland	**19**
Barry	**20**	Iron	**0**	Oceana	**48**
Bay	**393**	Isabella	**170**	Ogemaw	**326**
Benzie	**48**	Jackson	**40**	Ontonagon	**0**
Berrien	**0**	Kalamazoo	**0**	Osceola	**56**
Branch	**0**	Kalkaska	**268**	Oscoda	**450**
Calhoun	**79**	Kent	**145**	Otsego	**3,652**
Cass	**4**	Keweenaw	**0**	Ottawa	**155**
Charlevoix	**218**	Lake	**8**	Presque Isle	**39**
Cheboygan	**28**	Lapeer	**18**	Roscommon	**81**
Chippewa	**0**	Leelanau	**0**	Saginaw	**54**
Clare	**123**	Lenawee	**19**	St. Clair	**86**
Clinton	**0**	Livingston	**32**	St. Joseph	**0**
Crawford	**346**	Luce	**0**	Sanilac	**0**
Delta	**0**	Mackinac	**0**	Schoolcraft	**0**
Dickinson	**0**	Macomb	**9**	Shiawassee	**5**
Eaton	**9**	Manistee	**565**	Tuscola	**106**
Emmet	**0**	Marquette	**0**	Van Buren	**7**
Genesee	**18**	Mason	**21**	Washtenaw	**5**
Gladwin	**184**	Mecosta	**21**	Wayne	**7**
Gogebic	**0**	Menominee	**0**	Wexford	**13**
Gd. Traverse	**164**	Midland	**110**	**STATEWIDE**	**14,539**

Source: Michigan Department of Environmental Quality Office of Geological Survey

Michigan's Oil and Gas Fields

Source: Michigan Department of Environmental Quality, Geological Survey Division

II. Technological Hazards
B. Infrastructure Problems

The following list summarizes the broad types of infrastructure problems covered in this section:

1. Infrastructure Failures
2. Energy Emergencies
3. Transportation Accidents (air, rail, highway, marine)

A specific chapter is dedicated to infrastructure failures. Although various industrial hazards involve certain types of infrastructure (e.g. pipelines), and their breakdown, and this entire section of the hazard analysis relates to other types of infrastructure, the chapter specifically called infrastructure failures focuses upon interruptions in the provision of critical life-sustaining infrastructure, such as electricity and water supplies. As reported in a 2009 study by the National Academy of Sciences, an electrical blackout "has the potential to affect virtually all sectors of society: communications, transportation, banking and finance, commerce, manufacturing, energy, government, education, health care, public safety, emergency services, the food and water supply, and sanitation." Moreover, modern technological systems tend to be vulnerable to two trends that have been called "dependency creep" and "risk migration." These can be summarized as follows: "As systems become more complex, and as they grow in size, understanding and oversight become more difficult. Subsystems and dependencies may evolve that escape the close scrutiny of organization operators. Dependencies allow risk present in one part [of the] overall system to 'migrate' to others, with potentially damaging results. GPS and electric power systems have clearly accelerated dependency creep, and consequent risk migration. New technologies, such as nanoscale components, may not be adequately understood in the context of" existing risks to electric power systems.

One of the overarching patterns to be found within technical systems is the tradeoff between efficiency and vulnerability. Reserve capacity within a system can serve as a means for dealing with uncertainties and contingencies. In a competitive market environment, systems operate close to their full capacity and maximum efficiency during times when everything is functioning smoothly and predictably. Under such ideal conditions, "buffers shrink, costs fall, and profits rise," but when something in the operating environment breaks down, as in the case of a disaster or system failure, "unexpected developments perturb the system, finely tuned technical systems become brittle and have trouble operating outside relatively narrow parameters. Vulnerability can be the consequence of increased efficiency." Within this framework, solutions may involve the use of systems designed to include "excess capacity: costs are passed on to users and the society" as part of this operational design, rather than in the form of disaster response efforts after a failure has already occurred. Extra security may come at the expense of decreased efficiency, but the costs can be more fairly spread across the users of the technology, rather than concentrated in disastrous events. This problem of system management operates in an environment of "interdependencies, lack of knowledge, lack of slack, lack of trust, and lack of ways to overcome coordination problems." However, they key to the mitigation of problems in such complex systems can probably be found through addressing each of those conditions, point for point, and together as a whole.

> "Systems can quickly become dependent upon new technologies in ways that are unknown and unexpected by both developers and users… vulnerabilities in one part of the broader system have a tendency to spread to other parts of the system."

(The information and quotations in the preceding two paragraphs and text box were primarily obtained from "Severe Space Weather Events—Understanding Societal and Economic Impacts: A Workshop Report – Extended Summary," the National Academies Press, Washington DC, 2009.)

For the 2012 update of the MHA, new consideration has been given to aspects involving the safety and integrity of the built environment—bridges and structures—in addition to the traditional problems that had been covered in previous editions: broken water mains, sewage system breakdowns, and widespread and extended power failures. Energy emergencies are then discussed in a separate section, describing potential vulnerabilities involving

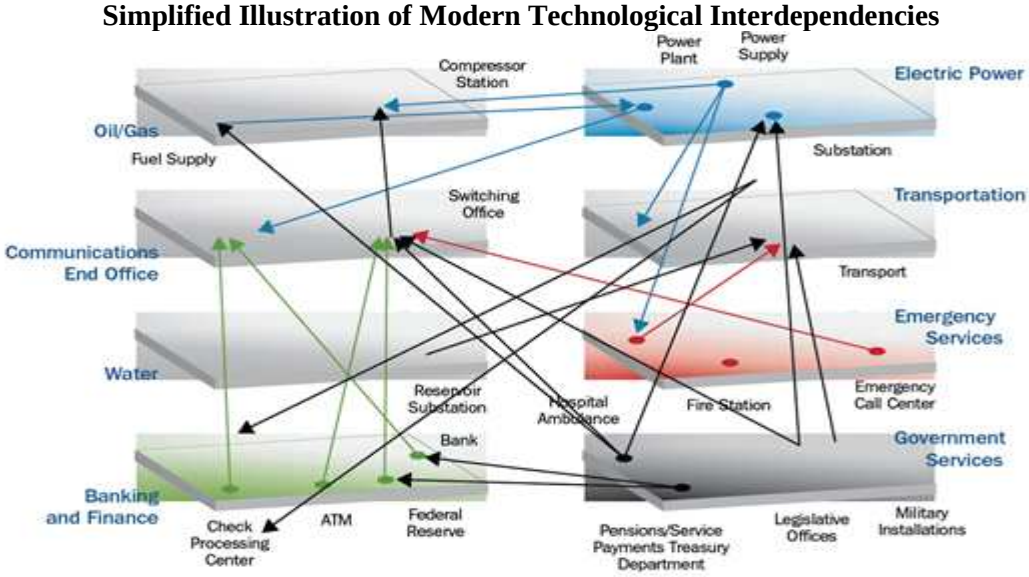
breakdowns in the availability of key energy sources that power most of our modern activities—especially gasoline, electricity, natural gas. Finally, the last section deals with major transportation accidents that might involve any of the major modes of our transportation system.

Overlap Between Infrastructure Problems and Other Sections of the Hazard Analysis

Some specialized forms of infrastructure are addressed in other sections of this document—dam failures appear in the Hydrological Hazards section because they can be a direct cause of flooding. Urban flooding is closely related to failures in the drainage infrastructure, and is included in the Hydrological Hazards section, as part of the Riverine Flooding chapter. Many of the ordinary means that enable weather hazards to be regularly endured (winds, storms, and extreme temperatures) involve the provision of adequate means of safely sheltering and transporting people, goods, and services in spite of such weather events. Storm events are a major cause of infrastructure failures, which then expose people more directly to the severe weather extremes that occur in Michigan's climate. Hail, ice, lightning, and strong winds have all caused breakdowns in electrical supply, for example, which in turn may expose persons to extreme cold or heat. Floods are often prevented through the use of drains and pumps and structures, and a breakdown in the functions of such infrastructure can lead to extensive flood damages.

There are cases in which various industrial accidents and technological hazards might arise from failures in the electrical or water supply system, which may be needed for the maintenance and cooling of complicated processes, and without which some disastrous fire, explosion, or release of hazardous materials might occur. Infrastructure failures may lead to energy shortages, a breakdown in vital health care, transportation, and communication services, thus having not only a costly economic impact but also putting lives at stake. Public health emergencies, in particular, may arise from the effects of a breakdown in sanitation infrastructure, or power failures that cause breakdowns in food supply and preservation chains (refrigeration, processing, and storage conditions). In addition to being able to hinder emergency response capabilities, infrastructure failures can also make it more difficult to maintain the effectiveness of law enforcement services, and thus enable criminal activities (e.g. looting) to increase. Certain types of civil disturbance or terrorism might be more likely to arise in circumstances involving lengthy power failures. Many types of catastrophic incidents would be expected to disrupt energy supplies or infrastructure in some way. Some types of hazards (e.g. earthquakes, space weather) are most likely to cause damage through their effects on Michigan's infrastructure, rather than in direct harm to humans. The space weather hazard in particular (addressed in the chapter on Celestial Impacts) needs to gain new recognition, because satellites have now become a type of critical infrastructure.

Simplified Illustration of Modern Technological Interdependencies



Source: Department of Homeland Security, through the National Academies Press

INFRASTRUCTURE FAILURES

The failure of critical public or private utility infrastructure that results in a temporary loss of essential functions and/or services.

Hazard Description

Michigan's citizens are dependent on public and private utility infrastructure to provide essential life-supporting services such as electric power, heating and air conditioning, water, sewage disposal and treatment, storm drainage, communications, and transportation. When one or more of these independent, yet interrelated systems fail due to disaster or other cause – even for a short period of time – it can have devastating consequences. For example, when power is lost during periods of extreme heat or cold, people can literally die in their homes if immediate mitigation actions are not taken. When the water or wastewater treatment systems in a community are inoperable, serious public health problems can arise that must be addressed immediately to prevent outbreaks of disease. When storm drainage systems fail, due to damage or an overload of capacity, serious flooding can occur.

These are just some examples of the types of infrastructure failures that can occur, and all of these situations can lead to disastrous public health and safety consequences if immediate actions are not taken. Typically, it is the most vulnerable members of society (i.e., the elderly, children, impoverished individuals, and people in poor health) who are the most heavily impacted by an infrastructure failure. If the failure involves more than one system, or is large enough in scope and magnitude, whole communities and possibly even regions can be severely impacted. (Note: Refer to the Dam Failures and Petroleum and Natural Gas Pipeline Accidents sections for more information on those particular types of infrastructure failures.)

Hazard Analysis

Infrastructure failures can affect hundreds of thousands of Michiganders when the conditions are "right" for a loss of critical systems. Melted transformers, ruptured pipes, crumbled bridges, and exploded transformers can cause inconvenience or havoc around the nation and the state, depending on the severity of the problem. The risk of infrastructure failure grows each year, as physical and technological infrastructure gets steadily more complex, and the interdependency between various facets of infrastructure (like pipelines, telecommunications lines, and roads) becomes more intertwined. Additionally, more vulnerable and aging infrastructure (rail lines, electrical components, bridges, roads, sewers, etc.) is in need of repair. Because of these reasons, large-scale disruptions in various components of infrastructure are likely. Major disruptions could lead to widespread economic losses, limit security, and altered ways of life.

Infrastructure failures can occur at any time and in any place in the state of Michigan. The metropolitan areas may be the most susceptible to interruptions in infrastructure, due to the additional volume of critical components of transportation, power, water, and telecommunication networks. Residents of these areas are also less likely to have adequate measures to "get through" infrastructure failures with generators, wood, and fireplaces. Economic losses from incapacitated business and industry are great in these areas. In northern regions of the state, there are fewer networks of infrastructure, but greater geographic areas are affected during infrastructure failures. Downed lines or blocked roads affect many more square miles than a similar occurrence around Detroit, but there are far fewer individuals and businesses at risk.

Although Michigan has in place many codes and standards that govern the design, construction and operation of public and private utility infrastructure, these codes and standards are often inadequate to protect the infrastructure from disaster-related damage. In many cases, the codes and standards call for the minimum level of structural integrity and operational performance recommended in accepted engineering practice, when a higher level would result in less disaster damage. Obviously, a balance must be reached between structural integrity, operational reliability, and short- and long-term costs associated with upgrading facility codes and standards.

It is possible to design and operate facilities that are virtually "disaster-proof." However, in many cases it is not economically feasible to do so. Too extensive of increases in integrity and reliability can result in prohibitive increases in cost. It is often too expensive to upgrade infrastructure codes and standards much beyond their current levels. However, in those cases where recurring, severe damage and system down-time occur due to natural or technological hazard events, it makes sense to explore the possibility of enhancing infrastructure design, construction, and operational codes and standards. The State of Michigan, in concert with public and private utility providers, is in the beginning phases of doing so through its statewide hazard mitigation efforts.

As Michigan's public and private utility infrastructure systems continue to age, infrastructure disasters will undoubtedly become more common. Because many of these systems were developed decades ago, the costs of repairing and replacing aging sections and/or components have greatly increased. As a result, many communities cannot afford to do the maintenance work necessary to keep the system in ideal operational mode. Increasing demands on the systems also lead to increased deterioration, and many components have far exceeded their useful service life. This creates a situation of increasing risk from infrastructure-related disasters, either as a primary event, or as a secondary event from floods, windstorms, snow and ice storms, or other natural or technological hazards. When those disasters do occur, they cause great inconvenience to the affected population and they can also create severe public health and safety concerns. Some urban deterioration includes missing manhole covers, sewer grates, chain link fences, and the occasional disappearance of signs from city streets. This type of issue is found more often in blighted neighborhoods. Cities already lacking in funds are forced to spend time and resources to mark the exposed manholes and sewers with construction barriers before they cause harm to vehicles and pedestrians. Workers also are forced to bolt down the covers and grates of cities' metal coverings.

The national economic downturn that began in 2007 has affected Michigan as much as any other state in the country, having the highest unemployment rate in the nation for many consecutive quarters. There will be less tax revenue, due to people leaving the state, the loss of jobs (particularly within the auto industry), and declines in property values, risking a loss of funding for construction/repairs. Michigan roads also suffer because of the fixed per-gallon gas tax (used to match federal funding and pay for road work) which stays constant, even when the costs of fuel and materials increase. Gas tax, diesel fuel tax, and vehicle registration fees collected in 2008 were the same as the amount collected in 1998. The effects of inflation contribute to a substantial reduction in the amount of (real) funds available for repairs. The 1946 to 1964 baby boom age cohort (defined by the United States Census) is currently approaching retirement age, or has already retired, and many may move to the southern United States for warmer weather, newer infrastructure, etc. which further threatens state tax revenue levels.

According to the Michigan Asset Management Council, the condition of 10,000 miles of Michigan's federal aid eligible roads went from either "good" or "fair" to "poor" between 2004 and 2007. According to the US Census Bureau, Michigan has been ranked in the bottom ten of all states for over 40 years in its level of funding. After a decade of stagnant revenues in road funding, the Michigan Department of Transportation (MDOT) showed an additional 15 percent decline in funding between 2008 and 2011. Another challenge for Michigan's roads and bridges is the annual winter freeze and thaw cycle that causes a continual breakdown of road and bridge surfaces. According to the July 2008 report by the Citizens Advisory Committee on Transportation Funding, Michigan's roads and bridges will require an estimated annual investment of $6.1 billion, which is nearly two times the current funding level, for basic improvements to its road and bridge system.

Transportation Funding Task Force (TF2)

The Transportation Funding Task Force was created in response to Public Act 221 of 2007 (P.A. 221 or Act 221), legislation which passed both the Michigan Senate and House of Representatives with a bipartisan majority and was signed into law in December 2007. The purpose of the Task Force, as defined by P.A. 221, is to "review the adequacy of surface transportation and aeronautics service provision and finance" in Michigan, review strategies for maximizing the returns on transportation investment, and evaluate the potential of alternative strategies to

replace or supplement transportation taxes and fees. A major and consistent focus of the group has been the need to stimulate economic activity and enhance personal mobility.

What the Task Force ultimately determined was that Michigan is approaching a crisis of infrastructure funding caused by the steady erosion of purchasing power, continued inflation in materials costs, and a decline in fuel-tax revenues due to spikes in gas prices, reduced travel, and a slowed economy. The decline in revenues, and a corresponding increase in demand for travel alternatives, has exposed the structural problems within the current mechanisms for transportation finance. For the past several years, the transportation revenue stream has been enhanced with bond revenues to provide a more robust level of investment. As a result, Michigan has made progress, particularly in improving the condition of the most highly used highways and bridges, but that bonding cannot continue without additional revenue.

Based on the information at their disposal, the Task Force could only conclude that much more investment in transportation is absolutely necessary. The Task Force learned that transportation agencies have been relentlessly vigilant in stretching their shrinking revenue. Their efforts may go unnoticed, because cost-cutting measures are designed not to disrupt service or impose on customers. Given the current state of the national economy, there is no guarantee that the federal government will come to Michigan's transportation rescue. Even if they did, Michigan is not in a position to take advantage of new federal funding. 2008 was the last year Michigan had enough state and local matching funds to claim all the federal transportation funding made available to the state. Some local agencies are already unable to make use of all federal transportation funding. In 2010 this became true across all transportation modes. Michigan must increase investment in transportation or past investment will be put at risk, and necessary infrastructure and transportation services will deteriorate.

The National Surface Transportation Policy and Revenue Study Committee recommended that investment in transportation by all levels of government should be at least $225 billion per year, an increase of 161 percent compared to national capital investment today of $86 billion. Michigan may lose up to $1 billion in federal funds each year, if transportation agencies do not have enough revenue to provide the required matching funds. The condition of Michigan's infrastructure would deteriorate, with 30 percent of Michigan roads predicted to decline into poor or fair condition during the next decade. The condition of airport pavement will also decline, with the average airport pavement already needing rehabilitation as of 2012, and crucial aviation safety programs threatened with termination or reduction in scope. Existing local transit services and intercity passenger rail services will be reduced, and intercity bus service to rural areas might be eliminated.

Restoring Michigan's investment in transportation has the potential to accomplish valuable and much needed changes. According the referenced study, the "good" level of investment was predicted to sustain 126,000 Michigan jobs, attract new businesses, and open new global markets for Michigan products and services. It will yield roughly $41 billion in other economic benefits for all sectors of the Michigan economy. For highways, roads and bridges, "good" investment will ensure that the most frequently used roads and bridges remain largely in good condition. For passenger transportation, a "good" investment level will allow transit agencies to begin replacing aging buses with greener, more fuel-efficient vehicles. It is estimated that congestion, poor pavement conditions, and crashes cost Michigan drivers and truckers $7 billion annually in wasted fuel, lost time, vehicle maintenance costs, medical costs, lost productivity, and property damage. Based on economic analysis conducted by the University of Michigan, the Task Force estimates that investment at the "good" level would provide an average Michigan household with an additional $2,000 per year in increased personal income and savings through reduced travel time and vehicle maintenance, and increased safety.

Two recent major engineering studies provide a glimpse of the extent of the infrastructure repair and rebuilding effort required just for Michigan to keep up with current and anticipated demand. The first study, completed by the American Society of Civil Engineers (ASCE) in 2009, found the results listed below.

Michigan's Top Three Infrastructure Concerns as of September 2008

1) Roads
2) Wastewater Infrastructure
3) Bridges

Key Infrastructure Facts

- 38% of Michigan's roads are in poor or mediocre condition, rated the 3rd worst state in the United States.
- In 2005, 39% of Michigan's urban highways were congested, compared to 23% in 2000.
- Michigan Department of Transportation will have a 15% decline in funding between 2008 and 2011.
- Michigan has the 8th worst road system in the nation, based on overall performance.
- Michigan is 6th in the nation in the total cost of road miles needed.
- A total of 23,000 road lane miles will need to be repaired or replaced by 2015, while expected funding will pay for only 876 lane miles, just 4% of what is needed.
- 25% of Michigan's bridges are structurally deficient or functionally obsolete.
- By 2030, unless additional roadway capacity is added, rush hour travel in major urban areas will take up to 50% longer to complete in Michigan.
- Driving on crumbling roads costs Michigan motorists a total of $2.6 billion per year.
- An additional 30% of Michigan roads will decline to fair or poor condition over the next decade.
- Under current funding mechanisms, Michigan stands to lose nearly $1 billion in federal funds each year, because its transportation agencies will not have enough revenue to provide the required matching funds.
- Michigan's drinking water infrastructure needs $11.3 billion over the next 20 years.
- Michigan's wastewater infrastructure needs $6 billion over the next 20 years.
- Michigan Department of Environmental Quality estimates that less than 40% of the State's stormwater infrastructure has even been reviewed for its impact on water quality.
- 52% of Michigan's schools have at least one inadequate building feature.
- There are 84 high hazard dams in Michigan. A high hazard dam is defined as a dam whose failure would cause a loss of life or significant property damage.
- A significant portion of the state's primary water distribution system is nearly 100 years old, with 80% of the city of Detroit's piping system having been installed before 1940.
- In 2007 alone, 26 billion gallons of raw or partially treated sewage spilled into surface waters in the state of Michigan, and 23 billion gallons, or 88% of the state total of sewage spilled into surface waters, were located in Detroit.

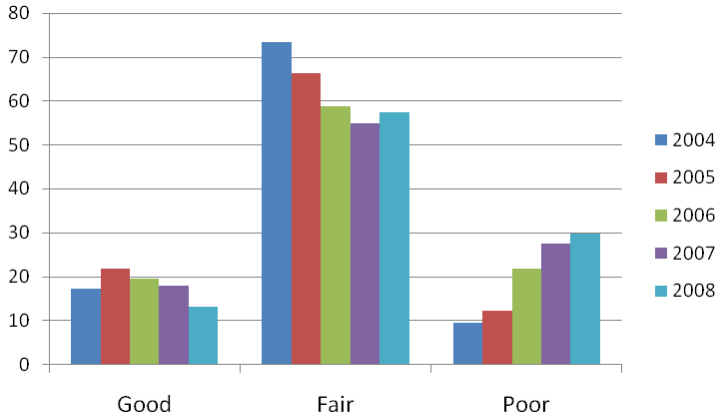
The ASCE study found a common thread nationwide of an increase in demands on public infrastructure without a corresponding increase in funding to perform the necessary maintenance and repairs on facilities, and to rebuild aging or dilapidated facilities.

Another study by the Southeast Michigan Council of Governments (SEMCOG), in 2005, estimated that the costs of replacing aging infrastructure and accommodating new growth in Southeast Michigan will likely top $26 billion over the next three decades, and may go as high as $70 billion when inflation and interest rates are added in. The study estimated that 60-70% of the region's sewers are more than 30 years old and will need extensive repairs or replacement to remain functional. (Nationwide, studies have shown it will cost $1 trillion to fix just the sewer problems alone in the United States over the next two decades.)

The Southeast Michigan Council of Governments (SEMCOG) showed survey data from 2004-2008 that documented a steady decline in the overall pavement condition of the major roads in Southeast Michigan.

Approximately 4,000 miles (10,660 lane miles) of the region's major roads were visually evaluated in 2008. Results of this survey indicate that 13 percent of the road network is in good condition, 57 percent is in fair condition, and 30 percent is in poor condition. SEMCOG also determined that gas tax revenues are declining in both the Federal Highway Trust Fund (HTF) and the Michigan Transportation Fund (MTF) because of higher gas prices causing people to drive less, increases in motor vehicle fuel efficiency and hybrid vehicles, and economic recession.

Road condition trends, 2004-2008, by percent of lane miles

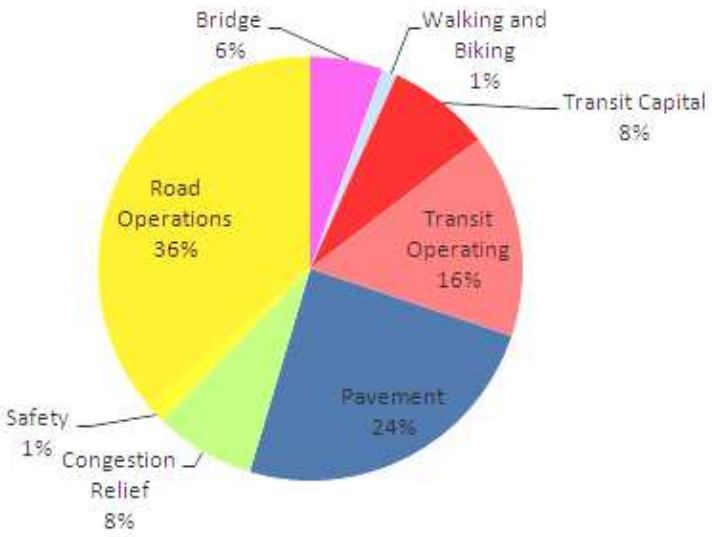


Southeast Michigan Council of Governments (SEMCOG): Direction2035

Direction2035 is the southeast Michigan region's long-range vision for transportation. It demonstrates how the transportation system can lend itself to improving the region overall by contributing to transportation goals, economic recovery, environmental health, community revitalization and stability, and quality of life. It consists of 1,850 transportation projects anticipated over the next 26 years, as well as policies and initiatives to be carried out by both SEMCOG and its partner agencies to keep moving the region in the right direction.

It is estimated that the region would need approximately $2.8 billion per year to address all identified transportation needs; but unfortunately, the region anticipates having only $1.3 billion per year available, a more than a 50 percent shortfall. Direction 2035 shows a need to make sure the region is using its limited funding wisely by addressing the highest priorities first, focusing on preservation of the existing system and implementation of the regional transit vision, and making transportation serve higher regional ideals. Direction 2035 has established the following transportation goals and objectives: enhance accessibility and mobility for all people; enhance accessibility and mobility for freight while maintaining community integrity; strategically improve the transportation infrastructure to enhance community and economic vitality; promote a safe and secure transportation system; and protect the environment, both natural and built.

The mixture of projects is designed to maximize regional goals and improve performance in those areas deemed most important for the region, including bridges, biking and walking facilities, transit, pavement, congestion, and safety. Also, Direction2035 calls for developing a regional transit authority to oversee an advanced transit system, helping local communities become safer and more walkable, coordinating transportation with water and sewer infrastructure needs, and maintaining a high level of security at our borders, ports, and airports. Projects are funded with a variety of federal, state, and local funds.



Michigan is a highly developed state. As such, it is highly dependent on public and private utility systems for the provision of essential life-supporting services, for the movement of people and goods, and for communications and the transmission of information. As a result, the possibility of infrastructure failure must be addressed in every Michigan community through wise system design and community development practices, and through prudent emergency preparedness that takes into account the issues and needs specific to infrastructure failures. In addition, the State of Michigan needs to continue to push for greater system reliability through its infrastructure-related hazard mitigation efforts. Although the problem of infrastructure failure will never be completely eliminated, it can certainly be greatly diminished through proper planning, design, construction, and maintenance practices.

Impact on the Public

Many forms of infrastructure are relied upon by the public, to provide the essential components of a productive modern lifestyle. The supply of fresh water (for drinking, cleaning, washing, cooking, and other uses) may sometimes be interrupted by pipe freezes, breaks, or water main failures. In addition to the need for citizens to find alternative sources of water, there is the potential for certain types of water system failures to allow contaminated water to be delivered and consumed, causing negative public health impacts. Pipe or water main failures may also cause localized damage, erosion, and flooding.

A failure of electric power systems may cause severe problems for persons who rely on medical equipment for their very survival, or for the maintenance of good health. A properly functioning power supply is also essential to maintain the safety of citizens who are working, traveling, attending to domestic matters, or involved in certain types of recreational activities. A sudden power failure may cause (1) traffic lights to stop functioning, (2) traffic patterns to slow dramatically (resulting in traffic jams and delays in emergency response capabilities), (3) interference with important communication networks and needed machinery (including other important infrastructure, such as sewer lift stations and hospital equipment), or (4) sudden darkness when vital operations are taking place or dangerous activities are being performed as a part of people's ordinary occupations and activities. Food storage and safety relies heavily on an ongoing supply of electrical power. A great many community events, business operations, and tourist attractions are similarly reliant upon electrical infrastructure.

Communication systems are vital for emergency response and operations, as well as a great many business functions and personal matters. Failure of communication systems may include (1) an area's mass media (conveying important emergency, health, public awareness, educational, recreational, and economic information), (2) its emergency 9-1-1 systems (allowing residents to quickly call for emergency assistance or to report

hazardous conditions), (3) its land-based and/or cellular telephone systems (inhibiting a great number of valuable communications), (4) the internet (an increasingly important means of communicating and running business operations), or (5) specialized radio communication systems (such as those used by police, EMS, and other vital service networks). The impacts include great inconvenience, lost personal and business opportunities, and various degrees of added risk throughout citizens' lives.

Drainage infrastructure failures may cause normally safe areas to become flood-prone, causing all the impacts of that hazard (described previously), but in locations beyond those that are recognized as floodplain and wetland areas. Often, "urban flooding" is the result, in which the drainage capacities of a built-up area are exceeded, and polluted waters back up into streets, basements, yards, parking areas, etc. This causes transportation and access problems, property damages, potential injuries and ill-health, cleaning costs and inconvenience, and the loss of irreplaceable records, artwork, photos and historic documents, and other personal articles. Another type of potential impact is environmental, when sewage processing capabilities cannot be adequately maintained and result in the deposition of untreated sewage into some part of the local environment, such as an area river.

The impacts of transportation infrastructure failures are dealt with in separate subsections elsewhere in this document, under categories such as transportation accidents, pipeline accidents, and hazardous material releases.

Impact on Public Confidence in State Governance

The failure of water systems, including "boil water" advisories or reports of actual or potential contamination, may have a disgruntling effect on some residents' confidence in government, although this would not necessarily be connected with Michigan state government unless it involves inadequate regulations or oversight of local utility providers. (Many water sources are private rather than public.) Some communities have decided to include water contamination issues as a hazard, in their local hazard mitigation plans.

Failure of the electrical power system would likely be similar to that of a water system in its effect, with some citizens being disgruntled and blaming "government," while others are served by private utilities that may be held responsible instead. So long as a power failure is very short and infrequent, most citizens probably have no problem overlooking it.

Failure of transportation systems, on the other hand, is generally considered to be an area of clear governmental responsibility, although the blame for failures will depend upon what kind of failure had taken place. Road maintenance can have local, state, and federal components. Transportation planning tends to involve both local and regional decisions, overseen by state and federal guidelines and regulations. When the safety of major bridges, highways, airports, and railroads comes into question, significantly more weight tends to be placed upon the role of higher-level (e.g. state and federal) agencies than local ones. A bridge collapse like the one that occurred in Minnesota would be expected to result in substantial amounts of dissatisfaction with government, and that event may have increased general concerns about the adequacy of bridges, nationwide. Otherwise, the public is probably more focused upon road conditions and individual driving behavior, rather than larger-scale transportation-related systems and regulatory issues (e.g. airlines, trains, ferries). Please refer to the Transportation Accidents subsection that follows.

Failure of communication systems is not likely to be extensively connected with confidence in government, due to the number of private firms involved, except where these systems are necessary for efficient emergency response and public warning functions during a hazardous situation.

Drainage and sewage infrastructure is most associated with local/county governments, and any dissatisfaction with the capacity of those systems is likely to be directed toward the appropriate agencies at that level, rather than toward the state and federal government. (Also see the subsections on dam failure and flooding, elsewhere in this document.)

Impact on Responders

Many forms of infrastructure are used by responders before, during, and after an emergency event. A good supply of water is needed for firefighting, and for certain types of hazardous materials response operations. Clean water is also used in the provision of emergency medical care, but special reserves of such water may have to be transported to the response sites (or special staging areas, in larger events), if the local water supply has been damaged or found to be insufficient. Water infrastructure failure may severely impede the normal operation of medical facilities, and may also lead to water contamination that poses the risk of public health emergencies.

Electrical power systems are used in most modern activities, and their failure may severely affect responders' notification, warning, and communications systems during an emergency event. Power failures that affect traffic signals can cause traffic jams that interfere with emergency response. Important equipment may need to be run by generator (or other alternative power sources) and thus cause certain types of operations to become more complicated to stage, and less effective. During nighttime events, extra difficulties may be created by the need to find alternative sources of artificial light, and the difficulties of dealing with looters may also be compounded.

Communication systems are vital for emergency operations and response, but are often very difficult to effectively sustain in an organized fashion during emergency events. An inability to convey messages between responders, officials, and the general public may cause preparedness, response, and recovery operations to be severely handicapped. Alternative means of communication are usually less effective and efficient, involving extra time and effort to be expended by responders who could otherwise be engaged in other productive activities.

Failures in drainage infrastructure may cause normally safe areas to become flood-prone, thus potentially causing flood hazards (described earlier) to interfere with responders' effectiveness, safety, and efficiency. The impacts of transportation failures are dealt with in separate subsections in this document (fog, transportation accidents, etc.)

Impact on the Environment

Public and private utility infrastructure failures can negatively impact the environment, as with wastewater collection and treatment facilities discharging various pollutants, contaminants, and raw sewage into the natural environment. Surface water and groundwater discharge facilities can negatively harm the environment with suspended soil sediments, dissolved chemical substances, or biological material, for example. Sewage disposal systems can back up or overflow, causing basement flooding. When sewage processing capabilities cannot be adequately maintained, it may result in the deposition of untreated sewage into some part of the local environment, such as an area river. Pollutants can lead to the poisoning of aquatic wildlife or the creation of vast dead zones, in receiving lakes and waters where there isn't enough oxygen for marine life to survive.

County and watershed drainage systems, and water conveyance and treatment systems, range from small agricultural drains to massive urban storm and sanitary sewer systems. These can contaminate the environment in the event of an infrastructure failure. Detention and retention basins, dams, flood pumps, irrigation diversions, and erosion control structures are also part of the infrastructure. These facilities vary from rural open channels, with drainage areas of several hundred acres, to large river systems with drainage areas of several hundred square miles.

Electric power and telecommunication facilities and systems can have environmental impacts stemming from tree trimming and clearance, the installation and maintenance of overhead lines, or when placing new distribution systems underground.

Significant Infrastructure Failures in Michigan

Unfortunately, Michigan has had its share of infrastructure failures, mostly due to the effects of natural disasters such as snow and ice storms, severe cold, windstorms, tornadoes, and floods. Michigan has had numerous widespread and severe electrical power outages, caused mostly by severe weather such as windstorms or ice and

sleet storms. (Note: Refer to those sections for more information on specific events.) Michigan has had several power outages in recent years that left upwards of 500,000 people (roughly 5% of the State's population) without power for periods lasting from several hours to several days at a time. Fortunately, most of those occurred during months when severe cold temperatures were not a problem. If they had occurred during the cold winter months, there certainly would have been a potential for loss of life – especially among the elderly and other more vulnerable members of society.

1978, 1980 Macomb Co., Oakland Co. Sewer Main Collapse

In 1978, and again in 1980, a large sewer main that served nearly 300,000 residential and business users in northern Macomb and Oakland Counties partially collapsed. The collapses were of such magnitude that continued sewer service to 300,000 users was in peril. Fortunately, officials were able to install temporary sleeves within the damaged main until it could be properly repaired. However, in order to relieve the back-pressure and keep basements from filling with sewage, officials were forced to divert millions of gallons of raw sewage into the Clinton River, fouling miles of Lake St. Clair beaches. Eventually, the damaged sections of sewer main were repaired, but this unfortunate incident caused tremendous disruption and environmental damage to the area. It showed how serious a large-scale sewer infrastructure failure in a densely populated area could be.

December 1989 Monroe County Water Supply Infrastructure Failure

The December 15, 1989 water emergency in Monroe was the result of a water intake in Lake Erie being blocked by ice build-up and Zebra Mussel crustaceans. Officials issued water conservation and boil-water advisories, and schools and most large businesses were closed. Local hospitals limited their activity to emergencies only and referred new patients to out-county hospitals. The hospitals operated on bottled water for the duration of the incident. The fire service was also adversely impacted, invoking mutual aid and stationing tankers throughout the city in case a fire occurred. The city eventually completed an emergency hookup with the Toledo, Ohio water system, which helped alleviate most of the water supply problems. The city also had three pumps drawing water from the River Raisin and pumping it to the water treatment facility. Emergency measures continued for three days. By December 18, the flow of water was back to normal. This incident showed how a vast public infrastructure system can be made inoperable – and thousands of people inconvenienced or even imperiled – by something as small as an aquatic mollusk.

July 7, 1991 Electric Power Infrastructure Failure

One of the major electrical blackout events due to storms was on July 7, 1991 when a powerful wind storm affected a large portion of central North America and knocked out power to over 1 million customers from Iowa to Ontario. Almost the entire lower half of the lower penisula of Michigan was affected by the derecho, with wind gusts of 65 to 85 mph. Electrical power was cut off to around 850,000 customers in Michigan alone, which was the largest number of customers to lose power from a single storm up to that time.

November 1992 Lansing Water Supply Infrastructure Failure

A Lansing water emergency occurred on November 15, 1992 when a transformer exploded, causing a power outage to portions of the city. Because a water pumping station was affected, officials were concerned about the loss of pressure and possibility of contamination within the water distribution system (which served Lansing and Delhi Township). Officials issued a boil-water advisory, and bottled water was distributed at four locations in the city. Local hospitals also had to be supplied with bulk supplies of fresh water to meet their normal operational needs. The water emergency was terminated the next day when tests indicated no contamination in the water supply.

Winter of 1993/94 Northern Michigan Water Supply and Sewer Infrastructure Failures

The underground freeze disaster in northern Michigan in 1994 provided an indication of how vulnerable our public water and sewer infrastructure can be to the adverse effects of natural phenomena. Due to a prolonged period of severe cold weather that caused ground frost to greatly increase beyond normal depths, municipal water and sewer systems in ten counties partially failed, disrupting service to over 18,000 homes and businesses and causing over $7 million in infrastructure damage. Some of the homes and businesses were without normal water and sewer service for several weeks. At final count, over 3,200 water and sewer lines had been frozen and/or broken, making this infrastructure failure not only unusual but also unprecedented in U.S. history in terms of scope and magnitude. This disaster showed how vulnerable our underground infrastructure can be when the "right" set of natural conditions occurs. Furthermore, these types of disasters may occur with greater frequency in the future, as our public infrastructure ages and thus becomes more fragile (and since most systems are not built to be "disaster resistant/disaster proof" in the first place).

June 1996 Thumb Area Drainage Infrastructure Failure

The June 1996 flood in the Thumb area, which resulted in a Presidential Disaster Declaration for seven counties, also can be considered an infrastructure disaster due to the severe impact on the drainage system in the region. Because the region's topography is relatively flat, there is extensive use of sub-surface tile and open drainage channels to make the land productive and usable. These drains are critical to the development of the region. Without them, much of the area would become economically useless swampland. The 1996 floods proved just how critical these drainage channels are to the local economy (both agricultural and non-agricultural) and to the citizens of the area. When the drains overflowed, surrounding farm fields were flooded—many for days—killing the crops that had just been planted and preventing further planting and cultivation. In addition, hundreds of culverts were damaged or destroyed and many roads and bridges were washed out, resulting in numerous road closures. The cumulative effects of these events included severe economic losses to both agricultural enterprises and supporting businesses and services. In addition, essential services and daily travel were disrupted, and physical damage to drains, culverts, roads, bridges and other essential facilities resulted in tremendous repair and replacement costs for the affected local jurisdictions.

December 1998 Detroit Natural Gas Infrastructure Failure

Sometimes, failure of one type of utility infrastructure is directly caused by a failure in another type of utility infrastructure. That was the case in Detroit on December 12, 1998, when a 30-inch water main in the downtown area burst, crushing a nearby 12-inch gas main and flooding it with water. Approximately 200,000 gallons of water flooded nearly 20 miles of gas line, shutting down gas service to hundreds of downtown Detroit businesses and residents on both sides of I-375. Officials estimated that 600 buildings (including hotels, offices, restaurants, shops, and residences) were affected by the gas service shutdown. Crews from Michigan Consolidated Gas worked around the clock for the next four days to drain water from the gas lines and hundreds of gas meters, to get gas service restored. Even after restoration was complete, problems and service interruptions continued to plague some structures for several days until more permanent repairs could be made. Michigan Consolidated Gas called the water contamination incident the worst in the company's 150-year history. Economic losses for the affected hotels, restaurants, and other businesses were substantial because the incident occurred during the normally profitable pre-Christmas holiday period.

May 31, 1998 Southern Michigan Electric Power Infrastructure Failure

On May 31, 1998 a derecho with winds averaging 60 to 90 mph (the highest being 130 mph) raced across lower Michigan, causing about 860,000 customers in Michigan to lose electrical power, and around 2 million across the United States. The 860,000 customers became a new historical record in Michigan, slightly exceeding the number of customers that lost power during the Southern Great Lakes Derecho of 1991. Some would not get power back for 10 days. For Consumers Energy utility company, which serves much of western and middle Lower Michigan, this derecho event was considered to be the most destructive weather event in its history.

June 1999 Oakland County Water Supply Infrastructure Failure

On June 7, 1999 a drilling company, hired to relocate fiber optic cable for a new highway interchange, accidentally broke a water main in the city of Auburn Hills, setting off a week-long water emergency that closed hundreds of businesses and schools and forced thousands of residents to boil water, or drink bottled water, until repairs could be made. Local officials estimated that 118,000 residents in over 44,000 households in Auburn Hills, Orion Township, Lake Orion, and Rochester Hills were affected by the water emergency. The crisis forced the closure of several major business enterprises, including the DaimlerChrysler headquarters and technology center, the Palace of Auburn Hills sports arena, and the 200-store Great Lakes Crossing Mall, idling thousands of workers. Businesses outside Oakland County were also affected because of a shortage of parts from suppliers with plants in Auburn Hills and Rochester Hills. Economic losses associated with the water emergency were so extensive that local officials gave up trying to calculate the costs. However, officials estimated that the weeklong ordeal likely caused losses in the tens of millions of dollars.

January 1, 2000 Statewide Y2K – Electric Power Infrastructure Failure

The most anticipated electric power failure in the history of humankind never actually occurred. The much-celebrated year 2000 (commonly known as Y2K) computer conversion crisis was considered by many to be the biggest "non-event" ever. Actually, several years of mitigation and preparedness efforts had paid off on the morning of January 1, 2000, when the electric power grid and other critical public utility systems remained operational – stemming fears that there would be widespread power outages, resource shortages, and economic and social chaos. The electrical grid in Michigan and across the country continued to operate on January 1 and beyond, without so much as a hiccup – a testament to the proactive efforts of the electric power industry.

June and August 2000 Detroit Electric Power Infrastructure Failure

Detroit fell victim to two significant power outages in 2000—one that began on June 13 and lasted for 4 days, and another that occurred from August 31-September 1. The two outages—the third and fourth major power failures in the city since 1991—caused significant disruptions in commerce and city services and (in the midst of impacts from other wind, storm, and flood events) again put the city in a negative national spotlight during a time of crisis.

The June 13-16 outage actually began on June 12, when one of three main lines connecting Detroit Edison to the Detroit Public Lighting Department failed. During the process of repairing the line on June 13, a cable connection failed, setting off a chain reaction that completely disabled the two remaining connections. The resulting outage cut power to 1,250 traffic lights, 42,000 street lights, Detroit Receiving Hospital, four senior housing complexes, all public housing, Detroit City Airport, the Renaissance Center, Wayne State University, Wayne County Community College, the Detroit Institute of Arts, the U. S. District Courthouse, the City-County Building, and most city buildings and schools. Businesses and homes that received electricity directly from Detroit Edison were not affected. The outage affected a total of 4,500 buildings, idled over 167,000 school children, caused significant business and parking revenue losses, and forced the city to pay out millions in overtime costs for city workers. The power outage also left some public schools without their electronic alarm systems, which resulted in four being broken into and vandalized.

The August 31 outage occurred when the Detroit Public Lighting Department cut electrical service to parts of the city (to avoid a widespread outage like the June 13-16 incident) after two generators failed due to high demand caused by hot weather. Power to municipal buildings and services was lost on much of the city's west side, and large portions of the east side, including schools, police stations, street and traffic lights, government offices, hospitals, and Wayne State University. Power was restored the next day. Follow up investigation revealed that a squirrel jumping on an electrical conductor may have caused an explosion at a substation that eventually led to the power failure.

July 2000 Mackinac Island Electric Power Infrastructure Failure

Beginning on July 22, 2000, Mackinac Island began to experience intermittent power outages that escalated into a complete power blackout two days later. The outage continued until July 28, when several large generators were brought to the island by Edison Sault Electric Company to provide temporary power until the island's electrical infrastructure could be repaired. The cause of the outage was later determined to be the overheating of five of the seven underwater cables that provided power to the island from the mainland. The damaged cables were subsequently replaced.

The outage came at the worst possible time for the residents, visitors, and businesses on Mackinac Island—at the height of the tourist season (with more than 35,000 tourists on the island) and during the week of the popular Chicago to Mackinac yacht race. Somehow, the island's businesses and visitors managed to cope, but not without significant inconvenience, additional operating costs, and some loss of revenues.

September 2000 Genesee County Drainage Infrastructure Failure

Heavy rainfall in Genesee County on September 22-23, 2000 caused the Thread Creek to flood and inundated the city of Grand Blanc's storm and sanitary sewer systems, as well as Genesee County's secondary sewer system. The city of Grand Blanc received 4.5 inches of rain in eleven hours, and the resulting flooding damaged nearly 50 homes and businesses. The Governor requested, and received, an SBA Disaster Declaration for this event, making available low-interest disaster loans to affected residents in Genesee County and the contiguous counties of Lapeer, Livingston, Oakland, Saginaw, Shiawassee, and Tuscola.

September 2000 Oakland and Wayne Counties Drainage Infrastructure Failure

On September 10 and 11, 2000, unusually heavy rainfall occurred in southeast Michigan, overwhelming municipal storm drainage systems and causing damage to 130,000 homes and businesses in Wayne and Oakland Counties. The majority of the flooding was due to sewer backups into homes and businesses, caused by short-term power failures at pumping stations, and by the capacity of the stormwater collection system being exceeded. As a result, raw sewage backed up into basements in at least 15 Wayne County communities, creating serious public health and safety concerns and causing widespread property losses. Due to the extensive damage and public health and safety threats, a Governor's Disaster Declaration was granted to Wayne County on September 20. On October 17, a Presidential Major Disaster Declaration was granted to Wayne County, making available disaster assistance to individuals and businesses that had incurred flood damage. On October 27, Oakland County was added to that Major Disaster Declaration.

February 2001 Genesee County Pump Station Failure

On February 14, 2001 a pump station in Genesee County went down for 34 hours, causing 2.5 millions gallons of raw sewage per hour to go into the Swartz Creek and Flint River. A health advisory was issued for high bacterial counts in the water. Power was lost, homes were evacuated, and nearly 1,000 reports were received regarding flooding. About 60 to 100 roads and bridges were temporarily closed and impassible due to the flood waters. There was nearly $2,000,000 in damage from pump station failures.

A total of over $213 million in disaster relief assistance was provided to individuals to pay for temporary housing, to repair flood related damages and replace essential household items, and for other necessary disaster related expenses. An additional $30 million in hazard mitigation assistance was also made available to the state, bringing the total public cost of this disaster to nearly $250 million.

March 2002 Wayne County Emergency Dispatch Failure

A small construction vehicle operated by a waterproofing worker accidentally ruptured a water line in the garage of police headquarters in Detroit. The water drained down into the basement, where it shorted out electricity and the telephone system in the dispatch center and on two other floors. Callers could not get help through the city's 911 police-and-fire dispatch center for more than two hours until a back-up call-in system was activated at Detroit City Airport.

September 2002 Oakland County Water Main Failure

A five foot diameter water main ruptured, lowering pressure to several thousand homes in southern Oakland County. A 20-by-20-foot section of pavement collapsed on 12 Mile Road, in Farmington Hills, as the water washed away the supporting soil. The pavement fell on top of a gas main, forcing the evacuation of a dozen nearby homes. Nearby trees were washed away and several utility poles were destabilized by the rushing water.

February 2003 Western Lower Peninsula Electrical Blackout

A break in a major transmission line caused a 60-mile electrical blackout that stretched over parts of six counties. The break cut electricity to tens of thousands of customers in the counties of Montcalm, Mecosta, Oceana, Newaygo, Muskegon, and northern Kent. The customers included hospitals, retirement homes, and schools. The power outage apparently started in the Croton-Hardy Dam area in Newaygo County. The power line that was cut normally supplies electricity to about 70 substations in the affected counties.

May 5, 2003 Wayne County Underground Explosions

In the City of Detroit, a massive explosion occurred just before noon, sending a couple of heavy manhole covers flying up above the ground in the area of Michigan and Griswold. It was believed that methane gas had leaked from a sewer line and accumulated, until ignited by a spark. Underground line insulation burned under the streets at Shelby and Lafayette. A firefighter who had been parked in a nearby fire truck was injured when the blast shattered the truck's windshield and side window and caused punctured eardrums. The explosions were at least four in number, and some electrical power had to be turned off in the area, in order to extinguish the fire.

August 2003 Northeastern United States Electrical Blackout

On Aug. 14, 2003, most residents of the northeast United States and Ontario were hit by the largest blackout in North America's history. Electricity was cut to 50 million people, bringing darkness to customers from New York to Michigan. Some essential services remained in operation in most of these areas, although backup generation in some cities was not up to the task. The phone systems remained operational in most areas; however, the increased demand by people phoning home left many circuits overloaded. Water systems in several cities lost pressure, forcing boil-water advisories.

Cellular telephones experienced significant service disruptions as their transmission towers were overloaded with a sudden increase in the volume of calls. Television and radio stations mostly remained on the air, with the help of backup generators, or by relaying their broadcasts through the Grimsby transmission towers, which were online throughout the blackout. Most interstate rail transportation in the United States was shut down, and the power outage's impact on international air transportation and financial markets was widespread. Meanwhile, the reliability and vulnerability of all electrical power grids were called into question. Total costs of the blackout have been estimated at between 4 and 10 billion dollars.

May 2004 Macomb County Water Main Failure

On May 18, 2004, a 36-inch water main broke in Macomb Township, leaving thousands of customers without water. It was the fourth time that this same water main had broken in the past four years. The break forced 20 schools to close, and shut down restaurants and other businesses. A boil-water advisory was put into in effect for several days.

July 2004 Marquette County Water Main Failure

One of two pipes, 16 inches in diameter, ruptured lengthwise just inches from the footing of the city's water treatment center. Water gushed out of the city's grid at a rate of 9,000 gallons per minute, drained both of the 500,000 gallon water towers, and eliminated pressure in all 85 miles of city pipeline. Electric service was not interrupted, although the city briefly shut down its power units, which are cooled with water, and reverted to a backup generator. A boil-water advisory was put into effect for several days.

January 2005 Muskegon County Water Main Failure

In January of 2005, most of the residents of the city of Muskegon Heights lost water service for a brief time. The cause of the failure was determined to be a broken water main.

August 2005 Crawford County Water Main Failure

A contractor working in the City of Grayling broke a 10 inch water main, causing a total disruption of water to the city as all well sites had to be shut down. Residents were told to boil water for several days, and water was restored to the city after repairs the next day.

May 3, 2006 Macomb County Underground Explosions

The downtown area was disrupted by underground power line explosions, when an excessive load was placed upon an old power cable. One blast sent a heavy manhole cover shooting through the air, but no injuries were reported from the incident. Persons were evacuated from the downtown area, amidst smoke from the blast. Electricity was restored by the next day, after maintenance crews worked on the problem overnight.

March 2007 Muskegon County Sewer Main Break

On Friday March 2, 2007 a break occurred in a 66 inch underground sewer main in Muskegon Township, resulting in flood damage to several homes and sending 25 million gallons of raw sewage into Muskegon Lake. The county hired crews to repair the ruptured pipe as soon as possible. Around 30 homes had to be evacuated. The county spent $38 million to replace eight and a half miles of underground sewer main.

September 2008 Genesee County Sewage Flooding

A September 13-14, 2008 weekend of pounding rain in Genesee County sent water and sewage flooding into hundreds of area homes and caused large-scale discharges into area rivers. There were over 400 calls of flooding, and water and sewage back ups in basements. There were also concerns about E. Coli bacteria in the water.

December 2008 Genesee County Sewage Spill

Over the weekend of December 27-28, 2008, an estimated 61 million gallons overflowed from a Flint retention pond into the Flint River. This was the county's biggest sewage spill in 2008. The spill was the result of melting snow and heavy rains over the weekend.

January 2009 Gogebic County Water Main Failure

On January 8, 2009, a 16 inch water pipe (a main that supplied the city) cracked due to pipe degradation. All schools in Ironwood were closed. Local health officials issued an advisory to conserve and boil drinking water, due to the water main break. Potable and non-potable water was available through Ironwood

Public Safety for delivery and pickup, and Gogebic Community College was open for assistance as well. Eventually, in the afternoon of January 12, 2009, all water was returned to normal.

December 31, 2010 – January 3, 2011 Wayne County Water Main Failure

Seventeen thousand residents of Highland Park lost running water over the 2011 New Year's weekend. In the early afternoon of December 31, 2010 a key water pump failed in the Highland Park treatment system, and that triggered the backup system, which draws from nearby Lake St. Clair. The inundation of water in the Highland Park system caused a massive rupture, leading to the loss of water pressure throughout the city. Residents were left without water for cooking, cleaning or flushing toilets. Those with water boiler systems lost their heat during the frigid temperatures. Spontaneous protests erupted in front of the city hall that afternoon, as residents became aware of the lack of water. A "boil water alert" was issued, warning residents that the water could be contaminated, and a state of emergency was declared in the city. The public schools were closed on the following Monday to avoid health concerns from the boil water advisory. The crumbling infrastructure throughout the Detroit area is becoming increasingly dangerous to the population, and upgrades or replacements to the system are needed.

February 23, 2011 Kalamazoo County Water Main Failure

A water main leak sent an estimated one million gallons of water flowing into a residential area on the west side of Kalamazoo, causing damage to homes and prompting police to close parts of West Main Street for about four hours. An estimated 40 homes had flooding damage to varying degrees.

June 9-10, 2011 Wayne County Electrical Blackout

Aging power transmission lines failed under the stress of high demand for electricity, due to multiple days of at least 90 degree heat. Some of Detroit's public buildings (including the municipal and court offices, a convention center, and Wayne State University) were blacked out on June 9-10th, 2011. Traffic signals were also blacked out, causing traffic issues, especially during the evening rush hour. The blackout provided a stark reminder of deteriorating infrastructure in a city already struggling to provide basic services.

December 2013 Statewide Electrical Power Infrastructure Failure

A massive ice storm hit Michigan shortly before Christmas, knocking out power to approximately 380,700 homes and businesses, some of whom were then without power for up to a week and a half. The outages came in waves, with the first hitting on the night of the storm and others following later on as ice weighed down tree branches and power lines which then broke. Consumers Energy, DTE Energy, and the Lansing Board of Water and Light were the hardest hit power companies. Consumers Energy said that the storm was the largest Christmas-week storm in the company's 126-year history and the worst ice storm in 10 years. Utility crews had a difficult time restoring power as more ice, snow, and frigid temperatures arrived after the initial event. The Michigan Public Service Commission began an assessment of the event, its aftermath, and the quality of response procedures used.

Bridge Failures

As Michigan's bridge infrastructure systems continue to age, infrastructure disasters will undoubtedly become more common. Because many of these systems were developed decades ago, the costs of repairing and replacing aging sections and components of bridges have greatly increased. As a result, many communities cannot afford to do the maintenance work necessary to keep the system in an ideal operational mode. Michigan is fortunate not to have suffered a major bridge collapse, but many areas in the United States have suffered such catastrophic failures, with casualties. A quarter of Michigan's bridges have been determined to be structurally deficient or functionally obsolete. Preparation for and awareness of a potential failure is important for mitigation purposes, so the following list covers the most significant bridge disasters in the United States (that might similarly occur at some point in Michigan).

Significant Bridge Failures in the United States

December 1967 Point Pleasant, West Virginia Bridge Failure

On December 15, 1967, the Silver Bridge collapsed while it was full of rush-hour traffic, resulting in the death of 46 people. The bridge, constructed in 1928, connected Point Pleasant, West Virginia and Kanauga, Ohio, over the Ohio River. Investigation of the wreckage identified the cause as the failure of a single eye-bar in a suspension chain, due to a small defect 0.1 inch deep. Analysis showed that the bridge was carrying much heavier loads than it had originally been designed for, and that it was poorly maintained.

May 1980 Tampa, Florida Bridge Failure

On May 9, 1980 in Tampa, Florida, during a blinding spring squall, the freighter Summit Venture rammed into the Sunshine Skyway and knocked out a 1,200-foot length of the bridge across the mouth of Tampa Bay. Thirty-five people, most of them in a Greyhound Bus, died as a result of the accident.

October 1989 Oakland, California Bridge Failure

On the afternoon of October 17, 1989, the Cypress Street (Viaduct) Freeway bridge in Oakland, California collapsed as a result of the Loma Prieta earthquake. The braces that held the upper-level to the lower-level broke in two and then fell outward, dropping the upper-level down on top of the lower-level with a force of approximately two million tons. Autos, trucks, and buses were crushed, along with their occupants. The collapse started in the northern sections of the freeway, and like a domino effect, each adjacent section began to collapse in turn. The collapse resulted in 42 fatalities.

September 2001 South Padre Island, Texas Bridge Failure

In the early morning hours of September 15, 2001, four loaded barges crashed into one of the Queen Isabella Causeway's support columns in South Padre Island, Texas, resulting in three 80-foot sections of the bridge falling into the water and leaving a large gap in the roadway. The collapsed sections were near the highest point of the causeway, making it difficult for approaching drivers to notice. Eight people were killed as their cars fell 85 feet into the water. Five vehicles were recovered from the water, along with thirteen survivors.

August 2007 Minneapolis, Minnesota Bridge Failure

On August 1, 2007 the I-35W Mississippi River bridge, a steel truss arch bridge that carried Interstate 35W across the Mississippi River in Minneapolis, collapsed during the evening rush hour. It collapsed into the river and onto the riverbanks beneath, killing 13 people and injuring another 145. The bridge was Minnesota's fifth busiest, carrying 140,000 vehicles daily. The NTSB cited a design flaw as the likely cause of the collapse, and asserted that additional weight on the bridge at the time of the collapse contributed to the failure.

Immediately after the collapse, help came from emergency response mutual aid within the seven-county Minneapolis-Saint Paul metropolitan area, and from charities and volunteers. City and county employees managed the rescue, using post-9/11 techniques and technology that may have saved additional lives. This failure stemmed from a major recent flaw and showed how this could happen in any location in the United States, including Michigan, with its significant number of "structurally deficient" bridges.

Structural Collapse (not terrorist or criminally motivated)

The collapse of part or all of any public or private structure or building is considered a structural failure. The level of damage and severity of the impacts is dependent on factors such as the size of the building, the number of occupants of the building, the time of day, day of week, the type of building use, on-site chemical storage, weather conditions, and the quantity of products stored in the structure. Along with misuse, accidents, and weather-related loads, the causes of failure may be found in deficiencies of design, detailing, material, workmanship, or inspection. Detroit is home to some of the oldest skyscrapers in the nation, with a total of 13 buildings over 300 feet tall that were constructed before 1930. The age of the structure is sometimes not related to the cause of the failure. With the aging of buildings, crumbling, deterioration, and collapse can occur at any height, either in the building's interior or its exterior. Funding is needed to repair several of the older structures. Enforcement of building codes can better guarantee that structures are designed to hold-up under normal conditions. Routine inspection of older structures may alert inspectors to "weak" points and will lessen the probability of a failure.

Physical hazards from electrical equipment, downed electrical lines, fire, explosion, noise, vehicles and heavy equipment, sharp objects, falling objects, hazardous materials, and uneven or unsteady working surfaces are a major cause of fatalities involving building collapses. Chemical and biological hazards can occur as well. The primary biological hazards include blood-borne pathogens and water-borne pathogens that present risks only in the event of direct contact with bodily fluids. Pathogens include bacteria, viruses, or fungi. Water-borne pathogens are organisms transmitted through direct contact with water sources that are most often contaminated with sewage. Blood-borne pathogens are transmissible only when blood or other body fluids from an infected person (living or dead) enter another person.

Fortunately, there has not yet been a major mass-casualty event in Michigan due to a building collapse, or even a partial collapse, but there have been incidents in other parts of the United States that resulted in numerous fatalities, some of which include criminal and terrorist attacks. Below is a list of structural collapses resulting in multiple fatalities from non-criminal and non-terrorist causes.

July 1981 Kansas City, Missouri Walkway Collapse

The Hyatt Regency hotel walkway collapse was a major disaster that occurred on July 17, 1981 in Kansas City, Missouri, killing 114 people and injuring more than 200 others during a tea dance. Approximately 2,000 people had gathered in the atrium to participate in and watch a dance contest. At 7:05 PM, the walkways on the second, third, and fourth floor were packed with visitors as they watched over the active lobby, which was also full of people. The fourth floor bridge was suspended directly over the second floor bridge, with the third floor walkway set off to the side, several meters away from the other two. The connection failed and both walkways crashed—one on top of the other, and then into the lobby below.

The cause of the accident was a flawed design change that doubled the load on the connection between the fourth floor walkway support beams and the tie rods carrying the weight of both walkways. This new design could barely handle the dead load weight of the structure itself, much less the weight of the spectators standing on it. The serious flaws of the revised design were further compounded by the fact that both designs placed the bolts directly in a welded joint between two facing C-channels, the weakest structural point in the box beams. Investigators concluded that the basic problem was a lack of proper communication between stakeholders. In particular, drawings that were only preliminary sketches had been interpreted as finalized drawings. The initial design had been accepted without performing basic calculations that would have revealed its serious flaws.

April 1987 Bridgeport, Connecticut. Building Collapse

On April 23, 1987, 28 construction workers were killed when a 16 story residential project under construction in Bridgeport, Connecticut, collapsed. Its partially erected frame completely collapsed, probably as a result of high concrete stresses on the floor slabs which resulted in cracking and a kind of punch-through failure. It was believed that this accident highlighted the deficiencies of the lift slab construction techniques used at that time.

June 2003 Chicago, Illinois Balcony Collapse

On June 29, 2003 in Chicago, Illinois, the deadliest balcony collapse in United States history occurred. Thirteen people were killed and another 57 were injured when an overcrowded balcony at a party collapsed. The second floor balcony collapsed onto the first floor, which itself collapsed into the basement below (30 foot total drop), carrying a total of around 100 persons between them.

Initial inquiries suggested that the collapse was probably due to overcrowding, but it was ultimately determined that poor construction was to blame. The balcony was one foot wider than codes had permitted, giving it too large an area. The balcony also had inadequate supports, was floored with undersized lengths of wood, and was attached to the walls with screws that were too short. The effects of age on the structure also played a role.

Programs and Initiatives

Following are brief synopses of some of the laws, programs and special initiatives aimed at preventing or greatly reducing the impacts of utility infrastructure failure in Michigan:

State and Federally-Assisted Infrastructure Mitigation Projects

The State of Michigan has been very proactive in its mitigation efforts for public infrastructure. Since 1994 the State has allocated over 32 million in federal Hazard Mitigation Grant Program (HMGP) funds for about 100 projects designed to address vulnerabilities in water, sewer, storm drainage, telecommunications, radio communications, and highway transportation infrastructure. For details, please refer to Attachment C in the 2011 Michigan Hazard Mitigation Plan.

Water Distribution Systems

Michigan's public water supplies are regulated under the Federal Safe Drinking Water Act. The Michigan Department of Environmental Quality, as a primary agency for the Federal government, provides supervision and control of Michigan's public water supplies (including their operation and physical improvements) under the Michigan Safe Drinking Water Act (1976 PA 399).

The Drinking Water and Radiological Protection Division of the MDEQ regulates, through a permit process, the design, construction, and alteration of public water supply systems. Water supply construction must be conducted within the framework of the Michigan Safe Drinking Water Act, as well as the Architecture, Professional Engineering and Land Surveying Act (1937 PA 240, which requires professional engineers to prepare construction documents for water works construction that costs over $15,000). Most communities in Michigan have, in conjunction with the MDEQ, developed water system master plans that conform to the requirements of the Michigan Safe Drinking Water Act. From a hazard mitigation standpoint, this is important because it helps ensure that all new water system construction, and alterations to existing systems, will conform to the minimum standards set in the Act. While not making water infrastructure "disaster-proof," the standards provide at least a basic level of design, structural, and operational integrity to new or renovated portions of a community's water supply system.

Wastewater Collection and Treatment Systems

The Federal Clean Water Act regulates discharge from community wastewater collection and treatment systems. The regulatory aspects of the Act that pertain to municipalities have been delegated to the MDEQ Surface Water Quality Division, for surface water discharge facilities, and the MDEQ Waste Management Division, for groundwater discharge facilities. Authority for the oversight of planning, facility design review, and construction permitting of sewerage systems collection, transportation, and treatment facilities is derived from Part 41 of the Michigan Natural Resources and Environmental Protection Act (1994 PA 451), and Administrative Rules promulgated under the authority of Part 41. The two MDEQ divisions assist local communities with the development and maintenance of their wastewater collection and treatment systems. In addition, they monitor and regulate these systems to ensure that pollution abatement and health conditions are met. Although the regulatory authority vested in the MDEQ is primarily aimed at preventing the pollution of the waters of the state, there are requirements in place under 1994 PA 451 regarding the design, construction, operational integrity, and reliability of wastewater collection and treatment systems.

The U.S. Environmental Protection Agency's (EPA) Technology Transfer Program, the "Recommended Standards for Sewage Works" developed by the Great Lakes-Upper Mississippi River Board of State Sanitary Engineers, and other technical references all provide important technical information to MDEQ personnel about the design and operation of wastewater collection and treatment system components. This information is used extensively by the MDEQ to review designs and operational procedures for the municipal wastewater program. Included within this guidance are basic minimum standards that help ensure an adequate level of structural and operational integrity for wastewater systems.

Surface Drainage Systems

Michigan's first drain laws appeared on the books as Territorial laws, years before Michigan had achieved statehood. After attaining statehood in 1837, the State passed its first drain law in 1839. Since that time, there have been 45 separate acts passed regarding drainage, up to the most recent recodification of drain law in 1956. Since 1956, the present drain code has been amended over 200 times—an indication of how important and dynamic the issue of drainage continues to be in Michigan.

The Michigan Drain Code provides for the maintenance and improvement of the vast system of intra-county (county) and inter-county drainage facilities. Each drain has a corresponding special assessment district (watershed), a defined route and course, an established length, and is conferred the status of a public corporation with powers of taxation, condemnation, ability to contract, hold, manage and dispose of property, and to sue and be sued. Drainage districts and drains are established by a petition of the affected landowners and/or municipalities. County drains, with a special assessment district entirely within the county, are administered by the locally elected County Drain Commissioner. Inter-county drains, with a special assessment district in more than one county, are administered by a drainage board that consists of the drain commissioners of the affected counties, and is chaired by the Director of the Michigan Department of Agriculture and Rural Development (MDARD) or an MDARD Deputy Director.

The intra-county and inter-county drainage program, administered by county drain commissioners and the MDARD, operates, maintains, and improves water conveyance and treatment systems—ranging from small agricultural drains to large urban storm and sanitary drains. (Note: Some drains are constructed of pipes that range in size from 12 inches in diameter to over 16 feet in diameter, with massive pumping stations that carry storm and/or sanitary sewage and serve thousands of residents. Other drains are open channels or ditches that vary from several feet in width, and being dry during part of the year, to large river channels in excess of 100 feet in width. Floodwater-retarding dams, flood pumps, erosion control structures, storage basins, and wastewater treatment structures are also part of the infrastructure constructed under the Michigan Drain Code.) Statewide, there are over 18,000 established drainage districts with an estimated combined length of over 40,000 miles of channel. These facilities vary from rural agricultural open channels, with drainage areas of several hundred acres, to large river systems with drainage areas of several hundred square miles.

As Michigan's villages, towns, and cities have grown, the drains that were primarily designed to serve agricultural needs have also been used to carry stormwater from municipalities and subdivisions, as well as to serve as outlets for sanitary treatment plants and a variety of other permitted discharges. The operation, maintenance, and improvement of drains in suburban and urban areas now provides for the management of stormwater, combined sanitary overflows, and sanitary sewage collection and treatment. Increasing demands on the drainage system in many areas of the State require that continuous improvements be made to enhance drain capacity and flow characteristics, reduce sedimentation, and improve structural integrity.

The Michigan Drain Code allows for landowners and/or municipalities to petition for the maintenance or improvement of drainage systems. Drain commissioners or drainage boards, in the absence of a petition, are allowed to maintain the drainage systems but are limited by law in the amount of money they are allowed to expend. The maintenance limit is equal to $2,500 per mile of established drain. This amount is generally sufficient for ordinary operations and maintenance, but is inadequate during times of widespread damage such as that which happens during a disaster. Because drainage districts stand on their own, money (or the maintenance limit) cannot be shared between districts. This greatly limits flexibility and can severely constrict drain reconstruction, improvement, and damage mitigation efforts in a post-disaster setting. Efforts are underway to amend the Michigan Drain Code to more adequately address current and anticipated future problems and concerns, and to make it more applicable to modern land development circumstances.

Electrical Systems

Disaster-related damage to electric power facilities and systems is a concern that is being actively addressed by utility companies across the state. DTE, Consumers Energy and other major electric utility companies have active,

ongoing programs to improve system reliability and protect facilities from damage by wind, snow and ice, and other hazards. Typically, these programs focus on trimming trees to prevent their encroachment on overhead lines, strengthening vulnerable system components, protecting equipment from lightning strikes, and placing new distribution systems underground. The Michigan Public Service Commission (MPSC) monitors the reliability of power systems to help minimize the scope and duration of power outages.

Telecommunications Systems

Like electric utility companies, telecommunications companies are concerned with the issue of protecting facilities and systems from disaster-related damage. Major telecommunications companies have programs to improve system reliability and physically protect facilities and system components from wind, snow and ice, and other hazards, using many of the same techniques as the electric utility companies.

Sewage System Overflows/Backups

Public Act 222 of 2001, Government Liability for Sewage Disposal Systems Backup, provides that under certain circumstances, governmental agencies that own or operate sewage disposal systems may be held liable for the overflow or backup of the system (e.g. basement flooding). The Act requires that persons seeking compensation for personal injury or property damage must show that all of the following existed at the time of the event:

- The municipality (at the time of the event) had owned or operated, or directly or indirectly discharged into, the portion of the sewage disposal system that allegedly caused damage or injury.
- The sewage disposal system of the municipality had a construction, design, maintenance, operation, or repair defect.
- The municipality knew, or in the exercise of reasonable diligence should have known, about the defect and failed to take reasonable steps in a reasonable amount of time to repair, correct or remedy the defect.
- The defect must be 50% or more of the cause of the event and the damage or injury.

Michigan Public Service Commission

The goal of the Michigan Public Service Commission is to assure safe and reliable energy, telecommunications, and transportation services at reasonable prices. In January of 2004, the Michigan Public Service Commission adopted new rules that require electricity providers to restore power to customers within 16 hours of a catastrophic event. Under the new guidelines, utility companies also must restore power within eight hours to customers who have lost it, if there is no catastrophic event. If the guidelines are not met, the utilities could face up to $20,000 for the first offense, up to $40,000 for the second violation, and up to $50,000 for a third offense. If companies do not restore power within 16 hours, homeowners will get a $25 credit, paid by the utilities, unless there is a catastrophe. A catastrophe is defined by the commission as severe weather conditions that knock out power to more than 10 percent of a utility company's customers; or when a state of emergency is declared by a local, state or federal government.

On September 1, 2009, the Michigan Public Service Commission completed a document called the Report on Status of Power Quality, to review performance measurements for evaluating the service, quality, reliability, and power plant generating cost efficiency of the electric utilities operating in Michigan.

Protection of Critical Michigan Infrastructure

The EMHSD/MSP spearheaded a statewide effort to identify and compile information on critical infrastructures in Michigan. Partners in this multi-faceted initiative include state agencies, local governments, federal agencies, and key private sector utilities, such as the electric power and communications industries. This multiyear effort is resulting in the development of a comprehensive list of critical public and private sector infrastructures that will provide the basis for subsequent actions designed to reduce the likelihood or potential impacts of a terrorist attack or other homeland security threats.

National Association of Regulatory Utility Commissioners (NARUC)

NARUC is an association representing the State public service commissioners who regulate essential utility services, such as electricity, gas, telecommunications, water, and transportation, throughout the country. As regulators, the members are charged with protecting the public and ensuring that the rates charged by regulated utilities are fair, just, and reasonable.

U.S. Army Engineer Research and Development Center (ERDC)

The Mission of the Engineer Research and Development Center (ERDC) is to provide scientific knowledge, technology, and expertise in engineering and environmental sciences to support the Armed Forces in their missions. ERDC has a featured service section specifically dealing with infrastructure-related issues, including programs such as the Concrete Technology Information Analysis Center (CTIAC), High-Performance Materials and Systems Selection, Materials Testing Center (MTC); and the Soil Mechanics Information Analysis Center (SMIAC).

Hazard Mitigation Alternatives for Infrastructure Failures

- Proper location, design, and maintenance of water and sewer systems (to include insulation of critical components to prevent damage from ground freeze).
- Burying electrical and phone lines, where beneficial and appropriate, to resist damage from severe winds, lightning, ice, and other hazards.
- Redundancies in utility and communications systems, especially "lifeline" systems; to increase resilience (even if at the cost of some efficiency).
- Separation and/or expansion of sewer system to handle anticipated stormwater volumes.
- Use of generators for backup power at critical facilities.
- "Rolling blackouts" in electrical systems that will otherwise fail completely due to overloading.
- Replacement or renovation of aging structures and equipment (to be made as hazard-resistant as economically possible).
- Physical protection of electrical and communications systems from lightning strikes.
- Tree-trimming programs to protect utility wires from falling branches. (Ideal: Establishment of a community forestry program with a main goal of creating and maintaining a disaster-resistant landscape in public rights-of-way.)
- Increasing public awareness and widespread use of the "MISS DIG" utility damage prevention service (800-482-7171).

Tie-in with Local Hazard Mitigation Planning

Because many means of implementing mitigation actions occur through local activities, this updated MHMP places additional emphasis on the coordination of State-level planning and initiatives with those taking place at the local level. This takes two forms:

1. The provision of guidance, encouragement, and incentives to local governments by the State, to promote local plan development, and
2. The consideration of information contained in local hazard mitigation plans when developing State plans and mitigation priorities.

Regarding the first type of State-local planning coordination, MSP guidance has included the “Local Hazard Mitigation Planning Workbook” (EMD-PUB 207), which is currently being updated for release by 2015. For the second type of State-local planning coordination, a section later in this plan summarizes hazard priority information as it has been reported in local hazard mitigation plans. Here, it will merely be noted that infrastructure failures were identified as some of the most significant hazards (often in connection with severe weather events) in local hazard mitigation plans for the following counties: Alger, Chippewa, Clinton, Gogebic, Ionia, Iosco, Isabella, Jackson, Kent, Keweenaw, Lake, Lenawee, Luce, Mackinac, Marquette, Mason, Newaygo,

Oakland, Oceana, Ontonagon, Ottawa, Presque Isle, Roscommon, St. Clair, Sanilac, Shiawassee, Van Buren, Washtenaw, Wayne, and Wexford.

Infrastructure Failure Guidance for Local Hazard Mitigation Planning

Whether the failure of electrical power, telephone, natural gas, water, sewage disposal, or transportation systems occurs as a primary stand-alone incident, or if the hazard occurs as a secondary result of extreme temperatures, snowfall, flooding, or winds—the risk of infrastructure failures is large. Infrastructure failures can affect hundreds of thousands of Michigan residents when the conditions are "right" for a loss of critical systems. Melted transformers, ruptured pipes, crumbled bridges, and exploded transformers can inconvenience or wreak havoc around the nation and the state, depending on the severity of the problem.

The risk of infrastructure failure grows each year, as physical and technological infrastructure gets steadily more complex, and the interdependency between various facets of infrastructure (like pipelines, telecommunications lines, and roads) becomes more intertwined. Additionally, essential repairs to vulnerable and aging infrastructure do not keep up with the growing volume of rail lines, electrical components, bridges, roads, sewers, etc. in need of repair. Because of these reasons, large-scale disruptions in various components of infrastructure are much more possible today than ten or twenty years ago. The risk of failure will continue to grow, and such major disruptions could lead to widespread economic losses, limit security, and altered ways of life.

Infrastructure failures can occur at any time and in any place in the state of Michigan. The metropolitan areas and the greater Detroit area are the most susceptible to interruptions in infrastructure, due to the additional volume of critical components of transportation, power, water, and telecommunication networks. Residents of these areas are also less likely to have adequate measures to "get through" infrastructure failures, with a lack of generators, wood, and fireplaces. Economic losses with incapacitated business and industry are much greater in these areas as well. In northern regions of the state, there are fewer networks of infrastructure, but greater geographic areas are affected during infrastructure failures. Downed lines or blocked roads affect many more square miles than a similar occurrence around Detroit, but there are far fewer individuals and businesses at risk.

To assess the risks of infrastructure failure in your locale, an examination of past infrastructure failures is very important. Have there been numerous power outages whenever there are severe winds? Do extremely cold or extremely cold temperatures strain or cause failures of water, gas, and electric resources? How often have various sewer, water, and electric lines been renovated? Is there a tree management program in place to limit structural damage during thunderstorms and winter storms? What are local regulations for new infrastructure? Questions such as these can be answered by contacting utility companies and municipal public services (city water and sewage). These companies/departments should have records of power and water failure incidents and can provide some answers on the age of infrastructure components. Information on service providers, service areas, and infrastructure details can be found through the Michigan Public Service Corporation, at www.michigan.gov/mpsc.

Transportation infrastructure concerns can be discovered through city and county road commissions, and through MDOT. Traffic volumes of major roads and information on recent and future projects can be found through the MDOT website, at www.michigan.gov/mdot. Contact of local engineering firms may be of interest to determine if there are any recent publications or studies of various infrastructure components in your community, as well.

ENERGY EMERGENCIES

An actual or potential shortage of gasoline, electrical power, natural gas, fuel oil, or propane—of sufficient magnitude and duration to potentially threaten public health and safety, and/or economic and social stability.

Hazard Description

An adequate energy supply is critical to Michigan's (and the nation's) economic and social well-being. The American economy and lifestyle are dependent on an uninterrupted, reliable, and relatively inexpensive supply of energy that includes gasoline to fuel vehicles, and electricity, natural gas, fuel oil, and propane to operate homes, businesses, and public buildings. Energy emergencies became a serious national issue in the 1970s, when two major "energy crises" exposed America's increasing vulnerability to long term energy disruptions. Americans have always dealt with short term energy disruptions caused by severe weather damage (i.e., downed power lines and poles), broken natural gas and fuel pipelines, and shortages caused by the inability of the energy market to adequately respond to consumer demand and meet needed production levels. However, the Oil Embargo of 1973-74, the natural gas shortage of 1976-77, the 1979 major price increases in oil resulting from the Iranian Revolution, the Gulf War in 1991 (after Iraq invaded Kuwait and destroyed many of its oil fields), and the aftermath of the September 11, 2001 terrorist attacks all forced the country to recognize its vulnerability to energy disruptions. That vulnerability was again exposed during the Great Blackout of 2003, when about 50 million electric customers in the northeast United States lost power due to a power grid malfunction. The oil price increases during 2007 and 2008 pushed American gasoline prices to over $4 a gallon and caused major economic and energy related issues as well.

There are three types of energy emergencies. The first and most frequent type of energy emergency involves physical damages to energy production or distribution facilities, caused by severe storms, tornadoes, floods, earthquakes, or sabotage. Michigan has experienced a number of these short-term energy disruptions in recent history, mostly due to high winds associated with severe thunderstorms, or damage caused by ice storms. While there have been only a few incidents of sabotaged energy systems in this country, networks supporting terrorist activity exist throughout the world and the possibility of more frequent incidents in the United States is always present. This category of energy emergency also covers short-term disruptions caused by human error, accidents or equipment failure, such as the power outages that occurred in Detroit in December 1998 and the Summer of 2000, the Wolverine Pipeline Company pipeline rupture in Jackson County in June 2000, the Mackinac Island power failure in July 2000, and the Great Blackout of 2003 that affected over 50 million energy customers. (Refer to the Infrastructure Failures, Pipeline Accidents, Severe Winds, and Ice/Sleet Storms sections of this document for additional information on short-term energy emergencies caused by weather, accidents, and equipment failure.)

The second type of energy emergency involves a sharp, sudden escalation in energy prices, usually resulting from a curtailment of oil supplies. Michigan experienced this type of energy emergency in the 1970s, due to events in the world oil market, and in 1990, following Iraq's invasion of Kuwait. The winter of 2000/2001 saw a sharp spike in natural gas costs, due to reduced availability. However, many Michigan customers were unaffected, due to a price freeze on Michigan's major gas utilities. When oil reserves in Louisiana were blocked during Hurricane Katrina (August 2005), the effects were felt in Michigan and the Governor issued a State of Energy Emergency due to a gasoline shortage. Since 2001, energy costs for the average U.S. household have more than doubled, and sharply escalating gasoline prices have again strained the budgets of lower and middle class families. The summer of 2008 had the highest oil prices on record, following a dramatic rise in prices from 2007 to 2008, and gasoline prices peaked at more than $4 per gallon. This contributed to the economic downtown beginning in 2007, as well as a move toward more fuel-efficient vehicles.

The third type of energy emergency is a sudden surge in energy demand caused by a national security emergency involving mobilization of U.S. defense forces. National defense, in a time of crisis, will demand an increase in

energy. Although the regulated natural gas and electric utilities have approved state and federal priority allocation systems that are in place, regulatory changes to introduce competition into natural gas and electric markets have not fully addressed how such shortages might be managed once these markets are fully opened.

Michigan uses coal, nuclear power, natural gas, renewable power, petroleum, and hydroelectric power for energy. The following table describes the usage of each type in Michigan, and compared to the rest of the United States.

Types of Energy Used: Michigan vs. U.S

Type	Michigan	U.S.
Coal	62.6%	51.0%
Nuclear	23.3%	20.1%
Natural Gas	10.2%	17.2%
Renewable Power	2.5%	2.1%
Petroleum	0.8%	2.8%
Hydro	0.6%	6.8%

Source: Michigan Public Service Commission

Hazard Analysis

America's early 21st Century energy situation is at a crossroads. Although energy issues came to the forefront in the aftermath of the 1970s "energy crisis," many energy issues still remain to be addressed. There have been tremendous strides in energy efficiency in homes and home appliances, and with automobile fuel efficiency, saving billions of dollars in energy costs, and our dependence on foreign oil imports has been decreasing, now roughly 45% of total oil consumption. World demand for oil is projected to increase 37% over 2006 levels by 2030, according to the 2007 U.S. Energy Information Administration's (EIA) annual report. Cars and trucks are predicted to cause almost 75% of the increase in oil consumption by India and China between 2001 and 2025. Auto sales in China have continued to grow and now match U.S. levels, resulting in part from economic growth rates around 10 percent for many years in a row. Although the Strategic Petroleum Reserve and other mechanisms have been put in place to reduce the negative consequences of another oil embargo or similar supply disruption, the possibility always remains for an event of near-equal magnitude and impact.

Total U.S. energy consumption has increased by more than 28% since the early 1970s – due mostly to relatively healthy economic growth, changes in commuter patterns, and an increase in the use of home and office computers and other electronic devices. In addition, a commuter-oriented lifestyle has also increased in Michigan. However, during that same period, the U.S. share of world energy consumption actually decreased from 31% in the early 1970s to approximately 25% in the late 1990s. In the 1990s, Michigan's total energy consumption grew over 14%. While this growth was slower than overall economic growth in Michigan due to increasing energy efficiency, growing economies have usually required increasing amounts of energy.

On the electric energy front, electric power system restructuring efforts, currently ongoing in Michigan and across the country, may be considered experiments involving increased competition, lower electrical rates, and increased production and reliability. According to the MPSC's Semi-Annual Appraisal of Energy Markets, issued in September 2008, Michigan's peak electrical demand will grow by 1.2% per year for the next 20 years, but this calculation was made before the 2007-2009 recession, which reduced electrical demand. As economic recovery continues, the demand for electricity should rise. This growth requires at least one new power plant by 2015, and at least three more plants built at a similar frequency, if renewable energy mandates and energy conservation measures are not employed. On the natural gas front, increases in the price of natural gas in Michigan and elsewhere, coupled with spot shortages of natural gas, are likely to renew the emphasis on home, commercial, and industrial energy conservation measures for that energy source.

Despite all these efforts, Michigan still remains vulnerable to short-term energy shortages, as was evidenced by the sharp price increases and decreased supply of gasoline caused by the June 2000 pipeline break in Jackson County and Hurricane Katrina in September 2005. Although other factors contributed to the shortages and price increases, the pipeline break again demonstrated our dependence on an uninterrupted energy supply to sustain our economy. The frequent short-term utility outages caused by severe weather, accidents, or equipment failure are another reminder of our dependence on energy in our daily lives. Although we eventually recover from these short-term energy shortages, it often involves considerable inconvenience and expense. The energy shortages faced by California in 2000/2001, in the wake of its electrical deregulation plan, proved that the country is vulnerable to power deficiencies. While California made many mistakes that have not been duplicated in Michigan and elsewhere, its situation again proves how critically important energy is to our national and economic security. In 2003, the Great Northeast Power Blackout provided another example of the vulnerability of our energy supply system in the United States. The late 2000s oil price increases have played a major role in the worst economic recession since the Great Depression, as well as the move for the automakers to build more fuel efficient and electric/hybrid vehicles.

Michigan has an excellent energy emergency planning program through the Michigan Public Service Commission. Many mechanisms have been put in place to reduce the impacts caused by short- and long-term energy disruptions. Indeed, Michigan's position as a major business, agriculture, educational, tourism, and industrial center requires that we continue to do so. However, even with those efforts, the threat of both short and long-term energy emergencies still exists in Michigan, due to our dependence on large-scale energy distribution systems to provide us with power.

Impact on the Public

Energy emergencies could cause the public, including small business owners and self-employed persons, to experience significant financial impacts from higher prices or limited/curtailed energy supplies. Business and commuting costs would be likely to increase temporarily. Persons with special medical needs may have difficulty traveling or otherwise having those needs met.

Impact on Public Confidence in State Governance

Portions of the public tend to infer government control and efficacy over market-related economic aspects of the situation. That is, many persons are unclear in their knowledge about limitations in the government's authority, responsibility, and effectiveness in situations that are substantially defined and shaped by a competitive private sector.

Impact on Responders

Energy emergencies may potentially affect response capabilities, through limitations or shortfalls in resources, and in the amount of expense associated with the use of such resources. A good example could be a shortage of fuel that is needed to operate fire trucks. The budgets of involved agencies may become overburdened. Resources may need to be carefully shared between agencies, or supplemented with special state or federal assistance.

Impact on the Environment

Principal air emissions involve substances that could cause a negative impact on the environment, such as particulate matter, sulfur oxides, nitrogen oxides, hydrocarbons, and carbon monoxide. Each of these pollutants varies in its emission rate and potential opportunities for reduction. Fossil fuel consumption is closely linked to greenhouse gas emissions and therefore climate change. The burning of fossil fuels results in the conversion of carbon to carbon dioxide, which contributes to the atmospheric greenhouse effect and global warming. Nuclear power plants generate radioactive by-products that can be harmful to the environment and must therefore be carefully stored in selected locations. The use of hydroelectric dams can also create negative consequences for aquatic wildlife, such as preventing fish from traveling upstream.

Energy Emergencies Affecting Michigan and Other States

Following are some energy emergencies that occurred in or affected Michigan and other states. Although the term "emergency" is used, it is important to note that not all of these events were officially declared as "emergencies" (e.g., "State of Emergency" or "State of Energy Emergency") under the applicable federal or state statute. However, each event fits one of the classifications outlined above.

November 9, 1965 Northeast United States "Great Northeast Blackout."

On November 9, 1965, the largest electrical blackout in U.S. history to that time occurred in the Northeastern United States when a single transmission line tripped near Niagara Falls, New York, setting off a series of failures that ultimately left 30 million people without power for as long as 13 hours. The outages occurred throughout New York, Ontario (Canada), most of New England, and parts of New Jersey and Pennsylvania. The lessons learned from this single event changed the way electric utility systems are designed and operated today. In addition, the National Electric Reliability Council – now called the North American Electric Reliability Council (NERC) – was formed in the wake of the 1965 Northeast Blackout to promote the reliability of the electricity supply for North America. (Refer to the Programs and Initiatives section below for more information on the NERC.)

October 1973-March 1974 Entire United States Middle East (OPEC) Oil Embargo

In October 1973 the Organization of Petroleum Exporting Countries (OPEC) – a Middle East oil cartel composed of most of the world's major oil producing countries – halted the flow of oil to the United States in retaliation for U.S. support of Israel in the 1973 Arab-Israeli War. From October 1973 to March 1974, OPEC maintained an embargo on oil imports to the United States and other Western nations that supported Israel, causing gasoline shortages and inflated oil prices. The embargo had a particularly negative effect on the U.S. economy and was one of the primary causative factors of the economic recession that plagued the country from 1973 to 1975. The OPEC embargo put the term "energy crisis" in the forefront of the news for months and forced the United States to seriously reevaluate its reliance on foreign oil imports and overall use of energy.

Winter of 1976-77 Entire United States National Energy Emergency (declared)

A natural gas shortage during the bitter winter of 1976-77 forced President Carter to proclaim a national energy emergency on February 2, 1977. President Carter did not mince words in his address to the nation on April 18, 1977 when he declared that combating the energy shortage was the "moral equivalent to war." Carter went on to urge the country to learn to prudently manage its shrinking energy supplies or be faced with potential future disaster. Carter proposed a plan that included strict conservation of fuel supplies, higher prices for oil and natural gas to reduce consumption, penalties for wasteful use of energy, and tax credits for the installation of solar energy devices. Carter also suggested that expansion of nuclear power should be the nation's last resort in seeking solutions to its energy problems. (Fortunately, Michigan was not as seriously affected by this emergency as many other states.)

July 13, 1977 New York City Electrical Blackout

On the night of July 13, 1977, New York City and parts of Westchester County to the north were plunged into darkness by an electric power blackout caused when four lightning strikes knocked out vital power lines feeding the city's power grid. Neighboring electric utility companies in New Jersey, New England and Long Island were automatically disconnected from the Con Edison power grid serving the city to prevent damage to their own systems, leaving the city's power grid as an "island" of electricity, separated from all outside sources of generation. (Con Edison is the utility that provides electric service to New York City.) The blackout, which lasted in some neighborhoods for 25 hours, came at a troubled time for New York City, and the reaction of the city's residents to the situation was marked with both resilience and violence. In many areas, neighbors helped neighbors and strangers helped strangers. However, other neighborhoods exploded into violence. Dubbed by some in the media as the "night of terror," the blackout brought out the worst in many of the city's residents as stores were ransacked, looted and destroyed, buildings were set on fire, and cars were stolen. The police, for the most part, could not stop the mayhem. Although they made over 3,700 arrests, most accounts indicate that thousands of perpetrators escaped before being caught. At the height of the blackout, over 1,000 fires burned throughout the city – six times the average rate – while at the same time the fire department was responding to 1,700 false alarms. Ironically, Con Edison had (and still has) one of the most reliable, least interrupted electric power systems in the United States.

March 28, 1979 Harrisburg, Pennsylvania Three Mile Island Nuclear Plant Accident

On March 28, 1979 the most serious nuclear reactor accident ever to occur at a commercial power plant in the United States occurred at the Three Mile Island nuclear power plant near Harrisburg, Pennsylvania. This incident resulted from a plant malfunction, combined with operator override of automatic safety systems. These errors resulted in a partial meltdown of the reactor core. Utility, state, and local personnel implemented response plans to protect the public in the area around the plant, while onsite efforts were undertaken to cool the reactor and eliminate any possible release of radioactive material. While this accident resulted in no off-site health consequences, it had a major negative impact on the continued development of the nuclear power industry in the United States.

Coincidentally, the Three Mile Island accident occurred two weeks after the release of the movie "The China Syndrome," which portrayed a nuclear reactor disaster. The combination of the movie, the accident, and a jury verdict later that spring against a Kerr-McGee nuclear facility in Oklahoma regarding plant safety raised new doubts in the mind of the public about official assurances of nuclear safety. As a result, support for nuclear power took a severe nosedive. In Michigan, plans by Consumers Power Company (now Consumers Energy Company) to complete a nuclear power plant in Midland were curtailed due to the public perceptions and constantly escalating development costs. Instead, the plant was converted to a natural gas fired facility.

1979-80 Entire United States Oil Price Increases

In 1979, the revolt in Iran against the rule of the Shah (dubbed the "Iranian Revolution") reduced world oil production and the OPEC nations announced a 14.5% increase in oil prices. By June 1979, OPEC again raised the average price of a barrel of oil by more than 50%, forcing the price of gasoline and fuel oil for American consumers to skyrocket, creating panic conditions in many parts of the country and causing a nationwide strike by independent truckers. The energy price increases resulted in long lines at gasoline stations, higher inflation, and signaled a reaffirmation of America's energy vulnerability.

During this time, federal price and allocation controls moderated the price increases and caused oil companies to allocate supply. For a period of several months, customers were only able to purchase 70 to 80% of their historical amounts. Under the federal allocation program, states had the authority to direct up to 3% of the monthly gasoline supply to meet the needs of priority users such as police, fire and emergency medical services, in addition to other emergency hardship needs. The State of Michigan redirected over 100 million gallons of gasoline, heating oil, and diesel fuel. The peak of the supply shortfall occurred in May 1979. Longer lasting, and ultimately more serious, was its role in the "double dip" economic recession of 1980 and 1981-1982, in which many lost jobs and manufacturing output was seriously depressed.

In response to the situation, President Carter proposed a plan, delayed by Congress for almost a year, which included conservation of existing fuel supplies, a long-range decrease in foreign oil imports, and the development of new sources of energy. Carter further proposed the deregulation of domestic oil prices in order to stimulate domestic oil production. However, Carter's deregulation plan didn't work as planned and instead resulted in American oil companies significantly raising gasoline prices. The combination of the higher price levels set by OPEC and the American oil companies caused gasoline and fuel oil

prices to nearly double. The start of war between Iran and Iraq in 1980 further boosted oil prices. By the end of 1980, the price of crude oil stood at 19 times what it had been just ten years earlier.

December 1998 Detroit Natural Gas Main Failure

On December 12, 1998 in Detroit, a 30-inch water main burst in the downtown area, crushing a nearby 12-inch gas main and flooding it with water. Approximately 200,000 gallons of water flooded nearly 20 miles of gas line, shutting down gas service to hundreds of downtown Detroit businesses and residents on both sides of I-375. Officials estimated that 600 buildings (including hotels, offices, restaurants, shops, and residences) were affected by the gas service shutdown. Crews from Michigan Consolidated Gas worked around the clock for the next four days to drain water from the gas lines and hundreds of gas meters and restore gas service. Even after restoration was complete, problems and service interruptions continued to plague some structures for several days, until more permanent repairs could be made. Michigan Consolidated Gas called the water contamination incident the worst in the company's 150-year history. Economic losses were substantial for the affected hotels, restaurants, and other businesses, because the incident occurred during the normally profitable pre-Christmas holiday period.

1999-2000 Northeastern United States Home Heating Oil Shortage

In mid-January 2000, a combination of adverse weather conditions, low heating oil inventories, natural gas capacity and delivery constraints, and production problems created rapid price increases in fuel oil and natural gas markets in the Northeast United States. When colder weather hit, consumers increased their demand for home heating oil and natural gas, and prices rose significantly. The temperature change increased weekly heating requirements by about 40%. Because fuel oil stocks were below normal levels, available supplies were limited and prices responded sharply to the increase in demand. The surge in home heating oil prices lasted for approximately four weeks and then subsided. However, the level and duration of the price increase prompted the President to ask the Secretary of Energy to examine opportunities for converting factories and major users from oil to other fuels, helping to free up oil supplies for use in heating homes. (Michigan also saw increased prices as supply was pulled from the Midwest in response to the higher prices in the Northeast.)

The federal government also took other actions to address the surge in heating fuel prices, including releasing funds from the Low Income Home Energy Assistance Program (LIHEAP) to relieve some of the financial burden to low income households. (Michigan was also a recipient of emergency funding from the LIHEAP.) The most significant action, however, occurred on July 10, 2000 when the Department of Energy established the Northeast Heating Oil Reserve. The reserve is intended to reduce future risks presented by home heating oil shortages from events such as this one. The maximum inventory of heating oil in the reserve will be two million barrels, which should provide relief from weather-related shortages for approximately ten days—the time it takes ships to bring heating oil from the Gulf of Mexico to New York Harbor.

June 2000 Jackson County Petroleum Product Pipeline Rupture

On the morning of June 7, 2000 a Wolverine Pipeline Company pipeline ruptured in Jackson County's Blackman Township, releasing 75,000 gallons of gasoline into the environment and forcing the evacuation of more than 500 homes in a one square mile area around the spill. The leak was detected when a drop in pressure was recorded at a metering station along the 80-mile pipeline that runs through Blackman Township from Joliet, Illinois to Detroit.

In addition to causing significant environmental and public safety problems, the spill shut down 30% of the state's gasoline transportation capability for nine days. The ruptured pipeline was capable of carrying approximately seven million gallons of gasoline per day. (This is equivalent to having 467 tanker trucks with a capacity of 9,000 gallons each making daily round trips from Jackson to Detroit.) While the pipeline was being repaired, tanker trucks from several surrounding states were brought in to help make up for the loss of the pipeline. As truck deliveries could not fully replace the pipeline transportation capacity, drivers began falling behind on deliveries and a growing number of gas stations were without one or more grades of gasoline for periods of time. The pipeline was not returned to service until June 17, and then at only 80% of capacity.

The pipeline rupture caused short-term supply problems in Southeast Michigan and, along with other factors, contributed to an increase in gasoline prices from an average of $1.68 per gallon, when the pipeline broke, to over $2.00 per gallon in the ensuing weeks of June. One of the major contributing factors to the shortages and price increases was that Michigan had very low gasoline inventories going into that summer. In some areas of the Midwest, inventories were 13.5% below average in May 2000—their lowest levels since 1981. The closing of the Total Refinery in Alma in December 1999 also contributed to the supply problem. The Alma refinery's capacity of just under one million gallons per day had satisfied approximately 8% of Michigan's average daily gasoline demand. The closing of the refinery increased Michigan's reliance on the Chicago area gasoline markets, thereby increasing the dependence on the Wolverine pipeline. A final contributing factor was a reduction in transportation capacity caused when one of the two barges supplying petroleum products to marine terminals in Traverse City, Cheboygan, and Bay City was in dry dock for repairs. Supply problems in northern Michigan and Bay City were eased once the barge returned to service in early June 2000. All of these factors combined to make gasoline supplies very tight even before the Wolverine pipeline ruptured.

June and August, 2000 Detroit Electrical Blackouts

Detroit fell victim to two significant power outages in 2000 – one that began on June 13 and lasted for 4 days, and another that occurred from August 31-September 1. The two outages (the third and fourth major power failures in the city since 1991) caused significant disruptions in commerce and city services and put the city in a negative national spotlight during a time of crisis (winds, storms, and flooding).

The June 13-16 outage actually began on June 12, when one of three main lines connecting Detroit Edison to the Detroit Public Lighting Department failed. During the process of repairing the line on June 13, a cable connection failed, setting off a chain reaction that completely disabled the two remaining connections. The resulting outage cut power to 1,250 traffic lights, 42,000 street lights, Detroit Receiving Hospital, four senior housing complexes, all public housing, Detroit City Airport, the Renaissance Center, Wayne State University, Wayne County Community College, the Detroit Institute of Arts, the U. S. District Courthouse, the City-County Building, and most city buildings and schools. Businesses and homes that received electricity directly from Detroit Edison were not affected. The outage affected a total of 4,500 buildings, idled over 167,000 school children, caused significant business and parking revenue losses, and forced the city to pay out millions in overtime costs for city workers. The power outage also left some public schools without their electronic alarm systems, resulting in four being broken into and vandalized.

The August 31 outage occurred when the Detroit Public Lighting Department cut electrical service to parts of the city (to avoid a widespread outage like the June 13-16 incident) after two generators failed due to high demand caused by hot weather. Power to municipal buildings and services was lost on much of the city's west side and large portions of its east side, including schools, police stations, street and traffic lights, government offices, hospitals, and Wayne State University. Power was restored the next day. Follow up investigation of the cause of the outage revealed that a squirrel jumping on an electrical conductor may have caused an explosion at a substation that eventually led to the power failure.

July 2000 Mackinac Island Electrical Blackouts

Beginning on July 22, 2000 Mackinac Island began to experience intermittent power outages that escalated two days later into a complete power blackout. The outage continued until July 28, when several large generators were brought to the island by Edison Sault Electric Company to provide temporary power until the island's electrical infrastructure could be repaired. The cause of the outage was later determined to be overheating damage to five of the seven underwater cables that provide power to the island from the mainland. The damaged cables were subsequently replaced to mitigate future problems.

The outage came at the worst possible time for the residents, visitors, and businesses on Mackinac Island—at the height of the tourist season (with more than 35,000 tourists on the island) and during the week of the popular Chicago to Mackinac yacht race. Somehow, the island's businesses and visitors managed to cope, but not without significant inconvenience, additional operating costs, and some loss of revenues.

2000-2001 State of California Electrical Blackouts

The energy deregulation efforts in California which began in 1996 took a nasty turn in late 2000 and early 2001 when the state began to experience power shortages and blackouts caused by the state's inability to purchase sufficient electric power supplies to satisfy demand. The blackouts often affected hundreds of thousands of customers at a time and created havoc for homeowners, business and industry, schools, banks, television stations, traffic control systems, and other major electrical users. The root cause of the energy emergency was the way in which California had designed and administered its deregulation plan in the first place. Under the plan, private utilities in the state had to sell their power plants and buy electricity on the open market, an approach that supposedly would result in lower electrical rates. However, the state's two largest private utilities—Pacific Gas and Electric Company and Southern California Edison—had lost at least $10 billion because of soaring wholesale prices for electricity and because rate caps imposed under deregulation had prevented them from passing those costs on to customers. As a result, both utilities were consistently short on power, as well as cash to pay their bills, and teetered on bankruptcy.

California's rapid growth in the 1990s (13.8%), coupled with the fact that no new power plants had been built since the mid-1980s, also contributed to the energy emergency. Had there been a glut of electricity on the West Coast, California's plan might well have worked as planned. Since there wasn't, the state's utilities had to compete for scarce, expensive power on the open market and then were not able to pass the extra costs on to customers.

Recognizing the seriousness of the situation, California's Governor declared a "state of emergency" in January 2001 and ordered the state Water Resources Department to temporarily buy up to $1 billion in power from electric wholesalers and provide it to the two utilities, to prevent continued blackouts. The Governor also signed a bill to amend the requirement that utilities sell their power plants under the state's deregulation plan.

California's energy deregulation experience provides an example of how problematic deregulation efforts can be if not properly designed and implemented. This has ramifications for states that have energy deregulation plans. In 2000, the Michigan Legislature passed the Michigan Customer Choice and Electricity Reliability Act and its companion Securitization Act (141 and 142 PA 2000). The two laws restructured Michigan's electric power supply system and gave the state's 3 million electrical customers the option of choosing their electricity supplier by January 1, 2002. Unlike California's plan, however, Michigan's deregulation plan does not impose strict rules on where the state's major utilities can purchase the power they sell. In addition, Michigan has a number of power plants that have been recently completed or are under construction.

December 2000 State of Michigan Propane Supply Problems

Going into the Winter of 2000-2001, propane supplies were very tight and inventories were low. In the Midwest, propane inventories in mid-October 2000 were 44% below the levels of one year earlier. In December 2000, the state experienced record cold weather. Heating degree-days showed that temperatures were 27 degrees colder than normal—the second coldest December on record and the snowiest on record. The propane industry found it increasingly difficult to maintain deliveries in light of the high levels of demand. In response to industry requests and in view of the heavy snows and very cold weather, the Chair of the Michigan Public Service Commission, in consultation with the Emergency Management and Homeland Security Division of the Michigan State Police, requested a 10-day waiver of limits on driver hour restrictions from the Regional Administrator of the Federal Motor Carrier Safety Administration. Waivers were granted for Michigan (and also Indiana, at their request). The extremely tight supply, coupled with additional demand to use propane as a substitute for natural gas (which also had a sharp run-up in prices), caused residential propane prices to reach a record high in Michigan of $1.76 per gallon in January 2001 before declining to $1.00 per gallon by the end of the heating season. A significant warming trend in January allowed the industry time to replace seriously depleted supplies. Had this not occurred, the situation could have become much more serious.

August 2003 Northeastern United States Electrical Blackout

On Aug. 14, 2003, much of the northeast United States and Ontario was hit by the largest blackout in North America's history, exceeding the Great Northeast Blackout of 1965. Electricity was lost by 50 million people, bringing darkness to customers from New York to Michigan. Some essential services remained in operation in most of these areas, although backup generation in some cities was not up to the task. The phone systems remained operational in most areas, but the increased demand by people phoning home left many circuits overloaded. Water systems in several cities lost pressure, forcing boil-water advisories. Cellular telephones experienced significant service disruptions as cellular transmission towers were overloaded with a sudden increase in the volume of calls. Television and radio stations mostly remained on the air with the help of backup generators, or by relaying their broadcasts through Grimsby transmission towers, which were online throughout the blackout. Most interstate rail transportation in the United States was shut down, and the power outage's impact on international air transportation and financial markets was widespread. Meanwhile, the reliability and vulnerability of all electrical power grids was called into question.

On November 19, 2003, the U.S.-Canada Power System Outage Task Force released an interim report placing the cause of the blackout on First Energy Corporation's failure to trim trees in part of its Ohio service area. The report said that a generating plant in the Cleveland, Ohio, area went off-line amid high electrical demand, and strained high-voltage power lines that later went out of service when they came in contact with overgrown trees. The report also found that First Energy did not take remedial action or warn other control centers until it was too late, because of a bug in the Unix-based General Electric Energy's XA/21 system that prevented alarms from showing on their control system, and they had inadequate staff to detect and correct the software bug. The cascading effect that resulted ultimately forced the shutdown of more than 100 power plants.

August 2005 State of Michigan Petroleum Product Supply Problems

On August 31, 2005, Governor Granholm issued three executive orders to address the energy-related issues in Michigan caused by Hurricane Katrina. The massive hurricane had blocked off oil refineries stationed in Louisiana and affected the supply in Michigan. Executive Order 2005-16 declared a State of Energy Emergency in accordance with 1982 PA 191. Executive Order 2005-17 temporarily waived regulations relating to motor carriers and drivers transporting gasoline, diesel fuel, and jet fuel. Executive Order 2005-18 provided for a temporary suspension of rules for gasoline vapor pressure. The State of Energy Emergency was in effect until November 29, 2005.

Winter of 2005-2006 United States Natural Gas Price Increases

During the winter of 2005-2006, Michigan saw record-high natural gas prices. Eighty percent of Michigan homes rely on natural gas as their primary heating source, and Michigan's average monthly residential heating bill from November to March increased from $128 a month the previous winter to $180 during 2005 and 2006. The reason for the high prices was largely due to both the lingering effects of Hurricane Ivan, in 2004, and 2005's Hurricanes Katrina and Rita. Substantial disruption of natural gas production in the Gulf of Mexico had reduced supply, driving up prices. There was further uncertainty about the prospect of even higher prices, depending on how long it might take to return natural gas production from the Gulf of Mexico to normal levels. Fortunately, prices did go down, averaging $152 a month for the 2006-2007 winter and the 2007-2008 winter. (Refer to the Natural Gas Prices Monthly Average Table from 2000-2009 for further details.)

2007-2008 United States Oil Price Increases

Crude oil prices reached an all-time high in Michigan in July-September 2008. During 2003, the price rose above $30 a barrel in the peak summer months, and reached $60 a barrel by August 2005 nationally. The dramatic rise in oil prices began in March of 2007, with a steady increase that included little break during the 2007-2008 winter's traditional low point. March of 2008 started a very large increase in oil prices, at just over $80 a barrel, then clearing $100 a barrel in May, and finally peaking at $147 a barrel in July 2008. Following the July peak, oil prices then took a dramatic dive, and by November 2008 returned to just under $40 a barrel, the lowest level since March 2005. (Refer to the Oil Price, January 2003-December 2008 table for further details.) The increase in prices led to gasoline prices of over $4 a gallon during the summer of 2008. Commentators attributed these price increases to many factors, including reports from the United States Department of Energy and others, the decline in petroleum reserves, concern about high demand for oil, Middle East tension, and oil price speculation. Also, deferred maintenance on refineries that escaped hurricane damage led to an increase in fires and accidents in 2007 and disrupted supplies. A reduction in routine refinery maintenance was made necessary by the need to operate near full capacity, to make up for a loss in refinery capacity from the 2005 Atlantic hurricane season. In 2008, Hurricane Ike played a role in the price spike. Rising demand from U.S. consumers had stretched refinery capacity to the limit and made the whole system more vulnerable to disruptions.

Winter of 2008-2009 United States Natural Gas Price Increases

During the winter of 2008 and 2009, Michigan saw nearly record high natural gas prices, similar to that of the 2005-2006 winter. State regulators attributed higher heating costs to the increased price of crude oil. Regulators said Michigan fared better than other states because Michigan stores some natural gas in underground tanks. The economic recession's higher unemployment rate, combined with higher heating costs, caused utility companies to shut off more power or natural gas because of unpaid bills. The number of gas shutoffs were up 39 percent in Michigan. (Refer to the Natural Gas Prices Monthly Average table at the end of this chapter for further details.)

Winter 2013-2014 Statewide Propane Shortages

Due to one of the harshest winters in Michigan in terms of extreme cold and higher than average snowfall amounts, Michigan residents struggled with propane shortages. The average cost of propane more than doubled from normal levels. The problem was exacerbated by (1) farmers' use of more propane to dry grain crops following a wet late harvest season during the fall, (2) pipeline disruptions and shutdowns, and (3) a rail closure in Canada. Heavy snowfall also made it difficult to deliver fuel by overland routes. Due to increased vehicle and equipment failures and hazardous road conditions, commercial drivers more easily hit their commercial driving limits, so on January 10th, Governor Rick Snyder declared an energy emergency, which suspended state and federal regulations on the number of hours and consecutive days that drivers can operate commercial vehicles. On January 19th, the U.S. Department of Transportation declared an emergency and relaxed transportation rules in Michigan and several other states until the emergency was over. The emergency declarations and transportation waivers in the Midwest were extended through March 1st. The Michigan Department of Natural Resources offered a program to issue firewood permits, which usually aren't sold during the winter. Some state-level efforts to address the shortage include $7 million in Michigan Energy Assistance Program funds devoted to "deliverable fuel heating assistance," and MDHS work to dedicate another $7 million to Low Income Heating and Energy Assistance Program (LIHEAP) assistance for residents who rely on propane or other deliverable fuels for heat.

Programs and Initiatives

The federal government has put into place a significant legislative and programmatic infrastructure, with and through the state governments, to address energy emergencies. Following are some of the more important components of that infrastructure:

Department of Energy Organization Act of 1977

The energy crisis of the 1970s demonstrated the need for a unified energy organization at the federal level. The Department of Energy Organization Act of 1977 (P.L. 95-91) brought the federal government's various energy agencies and programs into a single agency. The Department of Energy, established on October 1, 1977, assumed the responsibilities of the Federal Energy Administration, the Energy Research and Development Administration, the Federal Power Commission, and parts and programs of several other agencies. The Department of Energy coordinates and administers the federal government's energy functions, including research and development of energy technology, federal power marketing, energy conservation, the nuclear weapons program, energy regulatory programs, and a central energy data collection and analysis program.

Strategic Petroleum Reserve

America's "first line of defense" against a cutoff in oil supplies is the Strategic Petroleum Reserve (SPR) – an emergency supply of crude oil stored in huge underground salt caverns along the Gulf of Mexico. As of November 2010, the Strategic Petroleum Reserve had an inventory of 726 million barrels. This equates to 34 days of oil, at current daily US consumption levels of 21 million barrels a day. This system currently has the capacity to hold 727 million barrels. It is the largest emergency oil stockpile in the world, representing a $20 billion national investment in product and facilities. The total value of the crude in the SPR is approximately $66 billion. The price paid for the oil is $20.1 billion (an average of $28.42 per barrel).

The need for a national oil storage reserve was first recognized in the early 1940s. However, it took the 1973-74 OPEC oil embargo and the economic shock waves that followed to finally get the SPR established. President Ford set the SPR into motion when he signed the Energy Policy and Conservation Act (P.L. 94-163) on December 22,

1975. The legislation set forth a U.S. policy to establish a reserve of up to one billion barrels of petroleum. In July of 1977, the first oil was delivered to the SPR.

The Strategic Petroleum Reserve reduces the nation's vulnerability to the economic, national security, and foreign policy consequences of petroleum supply interruptions, such as was experienced in 1973-74. Decisions to withdraw crude oil from the SPR during an energy emergency are made by the President under the authorization of the Energy Policy and Conservation Act. In the event of an energy emergency, SPR oil would be distributed by competitive sale. The value of the SPR was tested in 1991, when President Bush ordered the first ever emergency drawdown of the SPR to dampen oil price hikes during the Persian Gulf War. The U.S. government's stated policy to withdraw oil early in a potential energy supply emergency makes the SPR a significant deterrent to oil import cutoffs, and a key tool of foreign policy.

National Energy Act of 1978

President Carter's goal of a comprehensive national energy program was achieved, at least in part, with the passage of the National Energy Act of 1978, which consisted of several separate pieces of legislation. The National Energy Conservation Policy Act (P.L. 95-619) set standards and provided financing for energy conservation in public and private buildings. The Power Plant and Industrial Fuel Use Act (P.L. 95-620) encouraged the transition from oil and gas to coal, in industrial and power plant boilers. The Public Utilities Regulatory Policies Act (P.L. 95-617) provided Congress with authority over the interstate transmission of electric power. The Natural Gas Policy Act (P.L. 95-621) unified the natural gas market and promoted the deregulation of the natural gas industry. The Energy Tax Act (P.L. 95-618) approved tax credits for the installation of solar, wind, and geothermal energy devices to promote energy conservation.

State Energy Conservation Program Improvement Act of 1990

Under the State Energy Conservation Program Improvement Act of 1990 (P.L. 101-440), states are required to submit to the U.S. Department of Energy an energy supply emergency planning program, consistent with applicable federal and state laws. The contingency plan provided by this program must include an implementation strategy or strategies (including regional coordination) for dealing with energy emergencies. In Michigan, this energy emergency planning requirement falls under the purview of the Michigan Public Service Commission (MPSC), an agency within the Michigan Department of Licensing and Regulatory Affairs. (See "Michigan Public Service Commission Energy Emergency Program" below for additional information.)

Michigan Public Service Commission Energy Emergency Program

The Michigan Public Service Commission (MPSC) is responsible for energy emergency planning and response in Michigan. The three MPSC divisions that are involved in energy emergency planning and response activities are the Management Services Division, the Regulated Energy Division, and the Operations and Wholesale Markets Division. The energy emergency responsibilities of these divisions can be grouped into four broad categories:

- Monitor Michigan's energy supply system for the purpose of detecting unusual imbalances that may indicate the potential for an energy emergency, and advise the appropriate state officials of such events.
- Develop, administer, and coordinate energy emergency contingency plans.
- Act as the communications focal point for federal, state, and local activities related to energy emergency planning and management.
- Maintain ongoing contact with the petroleum, natural gas, and electric industries concerning Michigan's energy situation.

In the event of an energy emergency, or in anticipation of such an emergency, the Chairman of the MPSC may consult with or convene and chair the MPSC Energy Emergency Management Team (EEMT), which consists of senior MPSC staff. The EEMT will monitor developments, prepare assessments, and develop responses. The MPSC Chairman will be responsible for consulting with or convening the EEMT, assigning tasks to its members, and providing information developed by the EEMT to the Governor. In general, the EEMT's responsibilities

include the monitoring of developments, preparation of assessments, and implementation of responses on a day-to-day basis.

Pursuant to 1982 PA 191 (The Declaration of State of Energy Emergency Act), the Governor may declare a State of Energy Emergency and order mandatory energy conservation actions following such a declaration. (See below for more information on 1982 PA 191.) In addition to declaring a State of Energy Emergency, the Governor may also declare a State of Emergency or State of Disaster under 1976 PA 390, as amended (The Michigan Emergency Management Act), and direct necessary actions through the Emergency Management and Homeland Security Division, of the Michigan Department of State Police. In that scenario, the MPSC plays a supporting role with situation monitoring, communications, and other activities. If a national energy emergency occurs, the MPSC is the primary coordinating agency with the U.S. Department of Energy's Office of Emergency Operations—the federal agency responsible for national contingency planning and response in the event of a nationwide energy shortage.

Public Act 295 of 2008

The Act promotes the development of clean and renewable energy and energy optimization through the implementation of standards that will cost-effectively provide greater energy security and diversify the energy resources used to meet consumers' needs. The Act encourages private investment in renewable energy, energy efficiency, and the improvement of air quality. Michigan Public Service Commission Temporary Order U-15800 was approved to implement the Act. It outlined formats for renewable energy plans, provided guidelines for requests for proposals (for gas and electric suppliers covered by plans), and addressed energy optimization plan implementation issues.

State Emergency Relief (SER)

The State Emergency Relief (SER) program provides a wide range of energy-related emergency services. The cost for SER energy services is covered with state and other federal funds. The SER program is administered by the Department of Human Services (DHS). An application is needed to request assistance and an appointment is generally required. Eligibility for SER energy services is based on a household's demonstration of immediate need for assistance with home heating fuel, electricity, or energy-related home repairs. This may involve a declared need for a deliverable fuel (such as fuel oil, liquid propane, gas, wood, or coal), presentation of a shut-off notice for natural gas or electricity, or a verified need for an energy-related home repair. In addition to immediate need, SER energy services eligibility is based on income to be received in the 30-day period following application. All households will have their income compared to the SER Income Need Standard that estimates the costs of shelter, heat, utilities, personal and incidental needs.

Energy Emergency Plans / Procedures

The MPSC develops and maintains three emergency procedure manuals for responding to energy emergencies pertaining to electricity, natural gas, and petroleum. (It is important to note that these three plans do not fully cover the wide range of events that could create an energy emergency in Michigan. For example, events involving military mobilization are not covered, nor are plans for responding to shortages of propane or fuel oil for residential users. If emergencies were to occur in those areas, the MPSC and other relevant state agencies would develop additional response actions as needed.)

The Michigan Motor Fuels Shortage Response Plan outlines a series of options that could be considered if Michigan is faced with a serious gasoline shortage, including measures designed to manage limited supplies and to reduce the demand for gasoline.

The Michigan Emergency Electrical Procedures consists of three sets of procedures for dealing with electricity shortages, each appropriate to a particular situation. The first set addresses *sudden or unanticipated short-term capacity shortages*, such as those experienced in the aftermath of severe weather that damages electrical production or distribution facilities. The second set addresses *anticipated or predictable short-term capacity*

shortages, such as those experienced during short-duration periods of hot weather when system demand is expected to exceed capacity. The third set addresses *long-term capacity shortages*, when it becomes necessary to live with a reduced supply for an extended period of time (more than a week).

The Michigan Natural Gas Procedures Manual outline procedures for addressing a long-term national gas shortage or an isolated disruption within the transmission or distribution systems.

State Energy Emergency Response

As indicated above, the Chairperson of the MPSC may convene the MPSC's internal Energy Emergency Management Team (EEMT) to coordinate response to an actual or anticipated energy emergency. Energy emergencies involving petroleum products, electricity, and natural gas supplies require specific actions unique to each. However, the MPSC has developed a series of response actions that are the same regardless of the energy source involved. The MPSC response to an energy emergency can be described in four phases, each phase specifying an appropriate level of mobilization to address a potential or developing emergency situation:

MPSC Response Phases

Phase I – Monitor and Alert

- Monitor/forecast supply, demand, and price.
- Alert of incipient problems.

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Phase II – Assess and Decide

- Assess the magnitude and implications of an emergency.
- Increase monitoring of the affected system/region.
- Evaluate available programs to deal with the emergency in economic, technical, and social terms.
- Select an appropriate program of response.

↓

Phase III – Action and Feedback

- Implement emergency programs.
- Continue monitoring.
- Evaluate output to determine if the contingency plan is successful.
- Initiate remedial action to plan, if required.

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Phase IV – Review and Lessons Learned

- Phase-out of emergency operations.
- Prepare after-action reports and conduct special analyses.
- Revise plans, if necessary.
- Resume routine monitoring.

Energy Supply Monitoring

Understanding and responding appropriately to an energy emergency depends on the availability of quantified information. For that reason, the MPSC monitors energy supplies and demand as a part of its emergency preparedness program. The MPSC tracks energy developments affecting Michigan, the region, and the nation through industry contacts, the DOE Energy Information Administration, the Internet, trade publications, and various statistical reports.

Historical and forecast data are published by the MPSC semi-annually in the *Michigan Energy Appraisal*, which provides an overview of the balance between energy supply and demand in Michigan and across the region. In the event of an actual or anticipated energy emergency, special updates to this basic publication can be issued to the EAC and MPSC EEMT as required to aid in decision-making during the response effort.

Public Information and Crisis Communications

As part of its energy emergency planning program, the MPSC maintains a public information program designed to help prevent confusion and uncertainty as well as enlist the support and cooperation of the public during an actual or anticipated energy emergency. The public information program is implemented at the discretion of the Governor and Chairperson of the MPSC at such time as a government response (whether voluntary or mandatory) is required. The public information program will provide the public with two basic sets of information: 1) an educational campaign to inform citizens about ways to minimize their use of energy and the inconvenience resulting from a disruption; and 2) an informational campaign to provide clear and concise information on the problems, and the steps being taken in response. In accordance with the Michigan Emergency Management Plan (MEMP), public information activities will be coordinated through a state Joint Public Information Team (JPIT) and Joint Public Information Center (JPIC).

Michigan Customer Choice and Electrical Reliability Act of 2000

Signed into law on June 3, 2000, the Michigan Customer Choice and Electrical Reliability Act (141 PA 2000) and its companion Securitization Act (2000 PA 142) heralded a new era of electrical energy restructuring in Michigan. The two laws cut electric rates for residential customers by 5%, imposed a 2 to 4 year rate cap for residential, commercial and industrial customers, created more competition among electrical suppliers, and increased electrical generation and reliability of the power supply. Acts 141 and 142 provided the foundation that allowed Michigan to restructure and deregulate its electric power supply system.

The Declaration of a State of Energy Emergency Act of 1982

The Declaration of a State of Energy Emergency Act (1982 PA 191) provides the Governor with the authority to declare a State of Energy Emergency to formulate an appropriate state response to an actual or anticipated energy emergency. The Governor may declare a State of Energy Emergency which remains in effect for the duration of the emergency or for 90 days, whichever is shorter. The State of Energy Emergency may be extended upon the approval of the Michigan Legislature, and it may be terminated by a majority vote of both houses of the Legislature.

When a State of Energy Emergency declaration is in effect, the Governor is authorized to:

1. Order specific restrictions on the use and sale of energy resources, which may include:
   - Restrictions on the interior temperature of buildings.
   - Restrictions on the hours and days during which buildings may be open.
   - Restrictions on the conditions under which energy resources may be sold.
   - Restrictions on lighting levels and the use of display and decorative lighting.
   - Restrictions on the use of privately owned vehicles, or a reduction in speed limits.
   - Restrictions on the use of public transportation, including directions to close a public transportation facility.

- Restrictions on the use of pupil transportation programs operated by public schools.

2. Direct an energy resource supplier to provide an energy resource to a health facility; school; public utility; public transit authority; fire or police station or vehicle; newspaper or television or radio station (for the purpose of relaying emergency instructions or other emergency message); food producer, processor, retailer or wholesaler; and to any other person or facility which provides essential services for the health, safety, and welfare of Michigan residents.

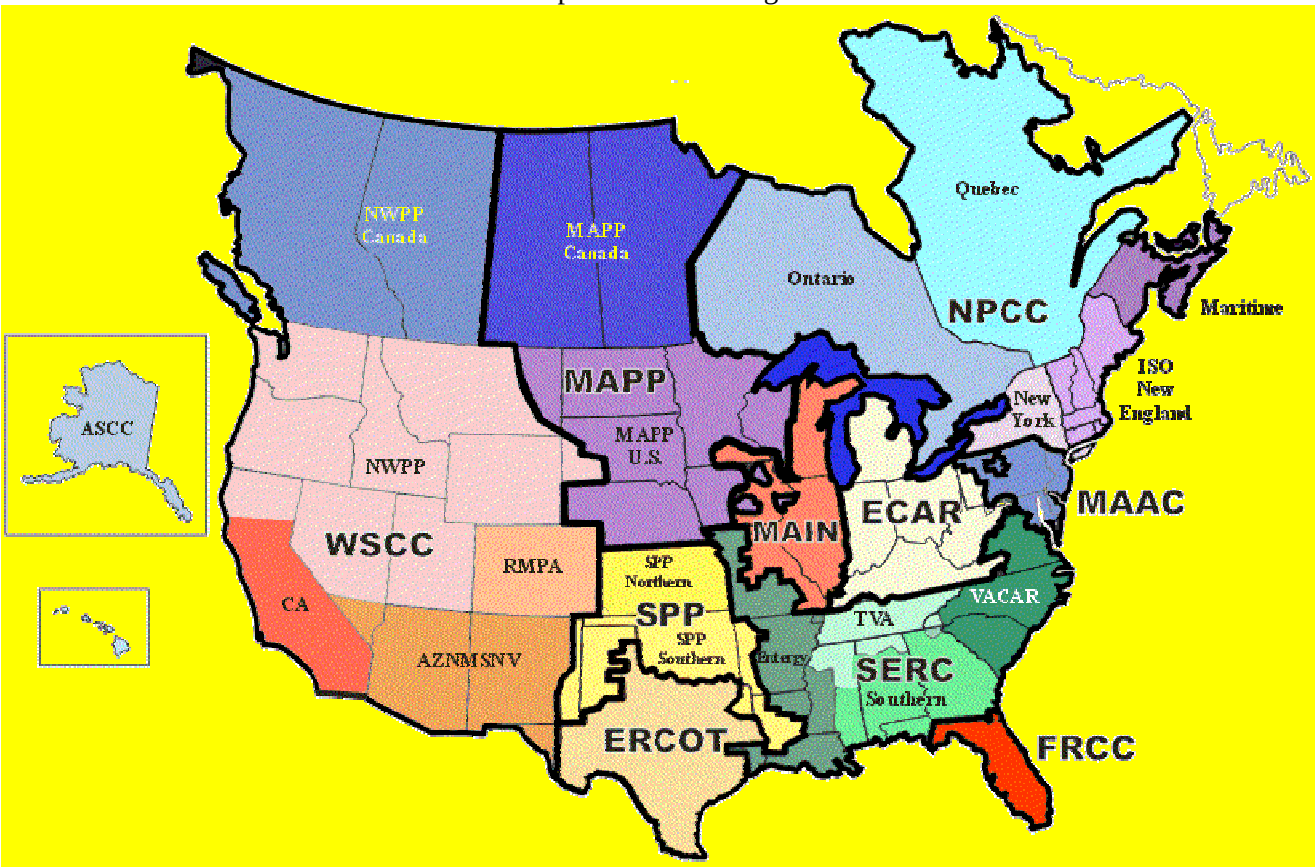
3. By Executive Order, suspend a statute or an order or rule of a state agency, or a specific provision of a statute, rule, or order, if strict compliance with the statute, rule, or order, or a specific provision of the statute, rule, or order will prevent, hinder, or delay necessary action in coping with the energy emergency.

North American Electric Reliability Council (NERC)

The NERC was originally created in 1968, in the aftermath of the Great Northeast Blackout of 1965, as the National Electric Reliability Council, and was renamed the North American Electric Reliability Council. The North American Electric Reliability Corporation (NERC), was formed on March 28, 2006 as the successor to the North American Electric Reliability Council (NERC). This association is composed of eight separate regional electric reliability councils. The purpose of the NERC is to ensure that electric utilities and other electricity suppliers work together to develop and maintain an adequate electric supply to meet the country's needs. NERC's primary responsibilities include working with stakeholders to develop standards for power system operation, monitoring and enforcing compliance with those standards, assessing resource adequacy, and providing educational and training resources as part of an accreditation program to ensure that power system operators remain qualified and proficient. The NERC and its regional reliability councils do this by reviewing past practices for lessons learned, monitoring present practices for compliance with applicable policies, criteria, standards, principles and guidelines, and assessing the future reliability of the nation's electric systems.

North American Electric Reliability Council

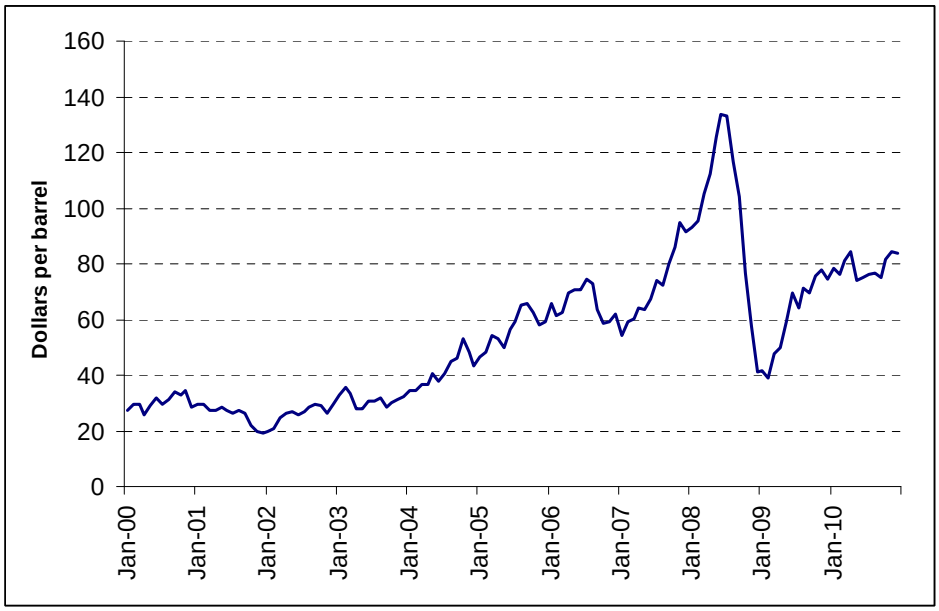
Map of Electrical Regions



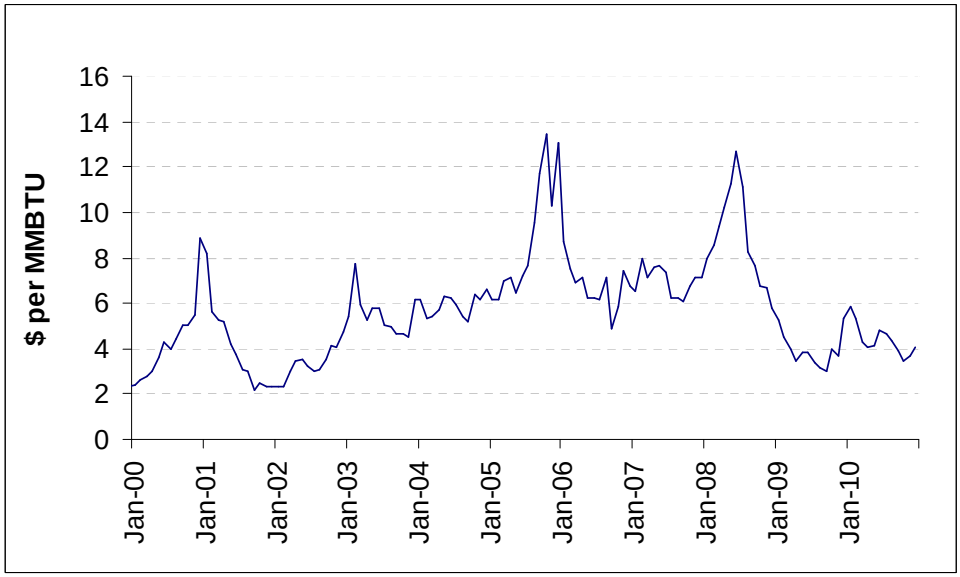
Hazard Mitigation Alternatives for Energy Emergencies

- Redundancies and alternatives in the energy supply system; provision of backup supply systems.
- The capacity to use more than one type of fuel to sustain necessary operations and functions.
- Use of alternative sources of energy (e.g. solar, wind sources) for key functions.
- Architectural designs that reduce the need for outside energy inputs.

West Texas Intermediate Crude Oil Price
January 2000 – December 2010
(U.S. EIA Short Term Energy Outlook)



Natural Gas Prices (Monthly Average, 2000-2010)
(Henry Hub pricing point)



Midwest Energy Consumption Patterns

NOTE: Energy Market Maps, Energy Infrastructure Maps, and Renewable Energy Maps were no longer provided publicly on the Energy Information Administration (EIA) web site, for national security reasons, and thus are not included in this document.

TRANSPORTATION ACCIDENTS

A crash or accident involving an air, land, or water-based commercial passenger carrier.

Hazard Description

Air Transportation Accidents

There are four circumstances that can result in an air transportation accident: 1) an airliner colliding with another aircraft in the air; 2) an airliner crashing while in the cruise phase of a flight due to mechanical problems, sabotage, or other cause; 3) an airliner crashing while in the takeoff or landing phases of a flight; or 4) two or more airliners colliding with one another on the ground during staging or taxi operations. When responding to any of these types of air transportation accidents, emergency personnel may be confronted with a number of problems, including: 1) suppressing fires; 2) rescuing and providing emergency first aid for survivors; 3) establishing mortuary facilities for victims; 4) detecting the presence of explosive, radioactive, or other hazardous materials; and 5) providing for crash site security, crowd and traffic control, and protection of evidence.

Major Land Transportation Accidents

A major land transportation accident in Michigan has the potential to create a local emergency event, or to seriously strain or overwhelm local response and medical services. It could involve a commercial intercity passenger bus, a local public transit bus, a school bus, or an intercity passenger train. Although these modes of land transportation have a good safety record, accidents do occur. Typically, bus accidents are caused by the bus slipping off a roadway in inclement weather or colliding with another vehicle. Intercity passenger train accidents usually involve a collision with a vehicle attempting to cross the railroad tracks before the train arrives at the crossing. Unless the train accident results in a major derailment, serious injuries are usually kept to a minimum. Bus accidents, on the other hand, can be quite serious—especially if the bus has tipped over. Numerous injuries are a very real possibility in those types of situations. Sometimes, "ordinary" highway crashes can be of unusual significance, when they either involve a large number of vehicles or in some manner cause the entire shut-down of a major highway for a significant period of time. (For example, on July 3, 2010, in the City of Flint, a tanker accident and fire caused I-475 to be closed down for many hours, in both directions.)

Michigan's High Speed Rail Program

In 1999, Michigan began the implementation of its High Speed Rail Program. As one of the first projects, train speeds will be increased from 79 miles per hour to over 100 miles per hour on a segment of Amtrak's passenger train route between Detroit and Chicago. The existing rail corridor between Kalamazoo and Grand Beach has been upgraded with improvements to the track, the signal and communication system, and the at-grade crossing warning devices. The state-of-the-art signal and communication system uses advanced technology to communicate between the at-grade crossings and the train, and also uses a Differential Global Positioning (DGP) train location system. These improvements will ensure the highest level of passenger safety. The goal of Michigan's High Speed Rail Program is to reduce travel time on the entire Detroit-to-Chicago rail corridor from approximately six hours to three and one-half hours. Future plans also include an increase in trip frequencies along the corridor, from the current four daily round trips up to eight or possibly even 10 daily round trips.

The fastest passenger trains now operating in the United States are on the Northeast Corridor, traveling between Washington D.C. and New York City at approximately 125 miles per hour. Although this high-speed passenger rail service is relatively new to the United States, similar systems have been in place for quite some time in Europe and Japan, with an outstanding safety record.

From a hazard perspective, the higher-speed train service will provide new challenges for communities on the Detroit-to-Chicago rail corridor to address in their emergency planning and preparedness efforts. To ensure that all communities are adequately prepared, the Federal Railroad Administration (FRA), the Michigan Department of State Police (MSP), the Michigan Department of Transportation (MDOT), and the affected communities'

emergency managers have all been working with the Operation Respond Institute to install an emergency information system along the corridor. This system is designed to quickly provide detailed railroad equipment information to emergency responders.

Water Transportation Accidents

A water transportation accident involving one of the 20 commercial marine passenger ferries operating from Michigan's Great Lakes shoreline communities could have significant life safety consequences. Most of these marine ferry services operate on a seasonal basis (typically May through November). Vessel sizes vary, but it is not uncommon for 100-200 passengers or more to be on board many of the ferries at the peak of tourist season. In a typical year, these ferries make thousands of trips across Great Lakes waters. Although the vessels have an excellent safety record and must pass rigorous Coast Guard inspections, the potential for an accident is always present. Accidents in other states or countries involving similar vessels validate the need for rigorous emergency preparedness actions to prevent loss of life in an open water setting such as the Great Lakes. For instance, the Ethan Allen tour boat that capsized in Lake George, New York, in 2005 took the lives of 20 senior citizens.

Hazard Analysis

The one commonality all transportation accidents share, whether air, land, or water-based, is that they can result in mass casualties. Air transportation accidents, in particular, can result in tremendous numbers of deaths and injuries, and major victim identification and crash scene management problems. Water transportation accidents, on the other hand, may require a significant underwater rescue and recovery effort that few local jurisdictions may be equipped or trained to handle. Michigan's fourteen Regional Planning Offices may have already performed an analysis of transportation in a particular area, and should be consulted for more information.

Air Transportation Accidents

Statistics from the NTSB and the airline industry show that the majority (over 75%) of airplane crashes and accidents occur during the takeoff or landing phases of a flight. As a result, developed areas that are adjacent to major airports, and along airport flight paths, are particularly vulnerable to this hazard. Accordingly, the greater the number of landings and takeoffs, the greater the probability of a crash or accident. The challenge for jurisdictions with a passenger air carrier airport is to develop adequate procedures to handle a mass casualty incident that could result from an airplane crash or accident.

The map at the end of this section shows the locations of Michigan's airports. Those airports are classified as transport airports, which are the most highly developed facilities in the state and have paved runways capable of handling jet aircraft. According to MDOT statistics, in 2010 these airports collectively handled over 28.2 million passengers (24.4 million from Detroit Metro alone). Nineteen airports have a greater probability of experiencing a commercial passenger airplane crash or accident, either at the airport or in the immediate vicinity of the airport, since these are the main takeoff and landing spots for such commercial flights.

Land Transportation Accidents

More than 130 certified intercity carriers provide passenger, charter, commuter, and special bus service directly to 220 Michigan communities. Of these carriers, six offer regular route service. Michigan's intercity rail passenger system consists of 568 route miles, along three corridors, serving 22 Michigan communities. (See the maps at the end of this section.)

Although these modes of land transportation have an excellent safety record, the combination of large numbers of passengers, unpredictable weather conditions, potential mechanical problems, and human error always leaves open the potential for a transportation accident involving mass casualties. Such an incident could occur with any of the aforementioned transportation modes, in any of the communities served by these systems. Nationally, an average of about six persons die each year in charter and commuter bus crashes, and 11 school children die in school bus accidents. About 8,500 children are injured each year in school bus crashes. Communities served by

any of these systems should plan for a land transportation-related mass casualty incident in their emergency preparedness efforts.

High Speed Rail: Future Challenges

The new high speed rail service between Detroit and Chicago will provide special challenges for communities located along that rail corridor. Although the rail infrastructure will be greatly enhanced and state-of-the-art safety improvements will be instituted, the possibility of a high speed collision between the train and an automobile or truck will still exist. Of special concern are the 360 public and private at-grade crossings in place along the 279 mile corridor. An at-grade crossing always involves the potential for a collision between the train and a vehicle attempting to drive across the tracks.

The U.S. Department of Transportation, through the Federal Railroad Administration, regulates the speed at which trains operate over highway/railroad at-grade crossings. These regulations allow trains to operate at up to 110 miles per hour over highway-railroad at-grade crossings with conventional warning devices only (cross buck signs, side of street and/or overhead flashing lights, and/or gates). At speeds between 110 and 125 miles per hour, positive barriers must be installed at highway-railroad crossings. At speeds above 125 miles per hour, all highways and railroads must be grade separated. These regulations were developed by evaluating the risk of accident damage, using the following philosophy:

- Up to 110 miles per hour: The highway vehicle occupant is most at-risk.
- 110 to 125 miles per hour: Possible injury to the train's occupants, due to rapid deceleration.
- Above 125 miles per hour: Greater likelihood of injury to train occupants, and the train may be derailed.

Amtrak, and high speed train manufacturers, have done computer simulations of accidents that could cause a significant rapid deceleration (similar to a highway vehicle-train accident). These simulations predict only minor injuries to the train's occupants. Based on the passenger train accident history in the state, the FRA regulations, and the computer simulations, the likelihood of a serious passenger rail transportation accident that results in significant casualties appears to be low. However, any collision between a train and a vehicle could result in casualties. Over a 10 year period from 2000 to 2009, there were 787 collisions in Michigan between trains and vehicles. It is only prudent that communities along the rail corridor be prepared to handle a mass casualty passenger rail accident as a worst-case scenario, and to plan for that contingency in their emergency preparedness efforts.

Water Transportation Accidents

A map at the end of this section shows the locations of Michigan's 20 marine passenger ferry services. These services have a good safety record, having never suffered a serious accident that resulted in loss of life or property. Nonetheless, given the large number of trips that are made over Great Lakes waters every year, the possibility of a water transportation accident involving one of these vessels is still a possibility. Furthermore, should such an accident occur, the often-turbulent Great Lakes waters, coupled with the potentially large number of passengers on board, could pose tremendous obstacles to carrying out an effective water rescue and recovery operation.

The U.S. Coast Guard, local law enforcement marine safety units, and the ferry operator would provide primary rescue response to a Great Lakes marine passenger ferry accident. These agencies are highly trained and skilled in water rescue operations, but their resources may not be sufficient or their efforts timely enough to save everyone should a fully loaded ferry sink. Even with on-board life saving equipment, some loss of life might be inevitable—especially in inclement weather and/or rough lake waters. In addition, hypothermia is a real concern—even in balmy Great Lakes waters in the middle of summer.

Impact on the Public

Although automobile crashes tragically kill many hundreds of Michigan residents each year, this analysis necessarily focuses on the types of accidents that are large enough in scale to potentially cause an emergency or disaster-level situation. Airplane crashes and train derailments pose the largest problems, with the potential to cause mass casualties and significant local property destruction—especially since these modes of transportation pass through densely populated urban areas. On a smaller scale, but still potentially devastating to smaller or rural areas, would be major highway accidents involving passenger buses that result in heavy casualties, with the potential to overwhelm smaller emergency medical systems in those areas. An event that might go almost unnoticed in a large and wealthy metropolitan area might easily overwhelm the resources of a poor or rural community. In certain cases, power equipment or other infrastructure may be damaged by such accidents, causing additional impacts (please refer to the section on infrastructure failures). Marine accidents have the most direct impact on human life, but may also discourage water-related tourism, if they receive enough negative publicity. Certain types of marine accidents may also involve a release of hazardous or environmentally damaging industrial materials (see hazardous materials section).

Impact on Public Confidence in State Governance

There may be a sense that improper regulation, authorization, or oversight was maintained by the state, following an event of significant size or impact involving mass transit providers such as trains, airplanes, ships, buses, or trolley/monorail systems. In the case of major accidents involving the highway system, there is often a perception that roadway capacities are too limited—either by design, lack of sufficient funding, or the effects of annual construction projects. Some may perceive that greater enforcement of laws and regulations (e.g. motor carrier) might have prevented a major incident from taking place.

Impact on Responders

Routine "fender benders" or personal vehicle accidents are usually handled by law enforcement officers and are not considered to be community-level emergency events (although they may cause traffic jams and delays that impede emergency response). Only when large numbers of vehicles or persons are involved would motor vehicle accidents be considered large-scale events with the need to engage community-wide response efforts. In very small or rural communities, an overturned bus could be considered a major transportation accident, if such an incident caused enough injuries that local emergency medical capabilities could not adequately handle the situation. Thus, in many ways, this sort of incident is an example of a "mass casualty" event that local and state emergency management programs train to handle.

The impact on responders in highway events is usually limited to the risks of being in and around moving traffic streams, and the diversion of limited resources into the handling of a single large incident. Larger-scale and more unusual events involve the crashing or breakdown of large air, rail, or marine transportation vehicles. A bridge or tunnel collapse, or huge interstate pileup involving dozens of vehicles, may also cause an emergency-level event to occur. In the case of large plane crashes or train derailments, responders may be exposed to fires and hazardous materials, and may encounter problems with looters. In cases involving marine transportation accidents, special rescue operations may occur under perilous weather and lake conditions, in a time-sensitive effort to rescue persons stranded in (usually chilly or freezing) lake waters before they drown or suffer harmful effects from hypothermia or exposure. In all major transportation incidents, which take place in the outdoors, responders will be exposed to the elements and may be plagued by extreme temperatures, hail, winds, or lightning for extended periods of time, when managing these events. (Each of these hazards is described more fully in other subsections of this document.)

Impact on the Environment

Transportation accidents on land, in air, or in water may impact the environment if toxins or chemicals are released. The burning of petroleum, in an accident that involves an explosion, will quickly release sulfur dioxide, oxidized nitrates, and carbon monoxide into the air. These gases contribute to climate change, ozone depletion,

and acid rain. Accidents involving watercraft may also cause a chemical release to occur. Similarly, an aircraft accident could spread petroleum and debris on land or in water.

Significant Passenger Transportation Accidents

As the following listings indicate, passenger transportation accidents occur with some regularity in Michigan. Fortunately, Michigan's recent transportation accidents have not been as deadly as accidents in many other parts of the country or around the world, but the possibility always exists for a major accident that results in multiple casualties.

October 28, 1942 Hamtramck (Wayne County) School Bus and Passenger Train Collision

During the morning of October 28, 1942, a major transportation accident occurred in Hamtramck when a school bus collided with a passenger train. The accident resulted in 16 fatalities and 27 injuries, and of the total of 45 bus passengers, only three were not injured. The driver of the bus claimed he did not see the approaching train because of an overcrowded doorway blocking clear visibility. The majority of the fatalities occurred near the back of the bus, and many of them were children headed for school.

January 14, 1950 Gaylord (Otsego County) Passenger Bus Accident

A bus collision during a severe snowstorm killed five persons and injured several others. A chartered bus returning 20 members of the Michigan Tech hockey squad from East Lansing to Houghton crashed head-on with a southbound Greyhound bus driving around an "S" curve. Both buses had bad damage, with the sides of each ripped open and some passengers thrown. All available ambulances and state police cruiser cars from the area and from neighboring cities were rushed to the scene. Some of the injured stayed in a hospital in Gaylord over the succeeding weeks.

August 19, 1951 Alpena (Alpena County) Passenger Bus Accident

A Greyhound bus, jam-packed with 40 vacationers bound from Mackinac City to Detroit, crashed head-on with a large beer truck in the outskirts of Alpena on highway US-23. The crash resulted in 10 fatalities and 27 injuries, and many of the bodies were reportedly so mangled that identifications were almost impossible.

Easter Sunday, 1958 Saginaw (Saginaw County) Passenger Airplane Crash

Prior to the August 1987 crash of Northwest Airlines Flight 255, Michigan's worst commercial passenger airplane crash had occurred on Easter Sunday, 1958, at Saginaw Tri-City International Airport. In that incident, which resulted in 47 fatalities, ice had built up on the plane's directional systems and the pilot was unable to reach the runway on the landing approach.

September 1976 Alpena (Alpena County) Military Airplane Crash

During one morning in September 1976, a military airplane tanker on a routine training mission crashed in a densely wooded swampy area. The violent crash had an expolsion described as a large ball of fire, followed by several more explosions which pulverized the plane into hundreds of pieces ranging from mere inches to ten feet in length. The accident resulted in 15 fatalities, but despite the severity of damage, there were five survivors.

March 4, 1987 Detroit (Wayne County) Passenger Airplane Crash

On March 4, 1987, a plane bound from Cleveland to Detroit crashed and skidded into three ground vehicles and caught fire. The cause of the accident was the captain's inability to control the airplane while descending on the final approach for landing. Nine of the 22 passengers died from a post-crash fire, lack of fire-blocking material, and poorly designed aircraft components.

August 16, 1987 Romulus (Wayne County) Passenger Airplane Crash

Michigan's worst commercial passenger airplane crash, and the seventh worst in U.S. aviation history (see the table below), occurred on August 16, 1987, at Detroit Metropolitan Airport. In that incident, Northwest Airlines Flight 255 was unable to gain sufficient altitude at takeoff and crashed onto nearby highway I-94, killing 156 passengers and crew. A small child was the lone survivor. A Governor's Disaster Declaration was granted to the City of Romulus and numerous state resources were mobilized to assist in the recovery.

December 3, 1990 Romulus (Wayne County) Passenger Airplane Crash

An unfortunate example of an airliner ground collision occurred on December 3, 1990, when two Northwest Airlines aircraft (Flight 299 and Flight 1482) collided with one another in heavy fog on a runway at Detroit Metropolitan Airport. The Flight 1482 aircraft was heavily damaged and caught fire. Eight persons died and 21 were injured in that incident.

March 10, 1993 Comstock (Kalamazoo Co.) Passenger Train Accident

On March 10, 1993, an Amtrak passenger train with 45 passengers collided with a liquid propane tanker truck in Comstock Township, killing the driver of the truck and injuring the train's engineer. The truck had been exiting a private drive when it slid into the path of the train, which was traveling eastbound at approximately 62 miles per hour. Upon impact, the liquid propane tank exploded with a large fireball. The train engine received considerable damage from the impact and explosion. The windows were blown out, causing the train engineer to receive second degree burns from the fireball. One passenger was transported to a nearby hospital for treatment. The private crossing at which this accident occurred, 11 other private crossings, and a public highway crossing in this area were all eliminated in 1996.

January 9, 1997 Monroe County Passenger Airplane Crash

On January 9, 1997 Comair Flight 3272, a commuter jet from Cincinnati, Ohio, bound for Detroit Metropolitan Airport, crashed on final approach in Monroe County, killing its 26 passengers and 3 crew. The plane was flying at approximately 4,000 feet on its approach when it suddenly and inexplicably did a barrel roll and nose dived, striking the ground 17 seconds later. The cause of the crash was determined by the National Transportation Safety Board to be failure on the part of the crew to adequately manage ice buildup on the wings.

July 9, 1999 Harrison (Clare County) Passenger Bus Accident

A tour bus filled with international exchange students slid off of rain-slicked highway U.S. 27 near Harrison, injuring 40 passengers. Most of the injured were treated and released at a nearby hospital. One passenger was hospitalized overnight, with an eye injury.

July 31, 1999 Marine City (St. Clair County) Passenger Airplane Crash

A commercial skydiving plane crashed shortly after its takeoff from Marine City Airport, killing all 10 persons aboard. The plane was carrying its pilot and nine skydivers, who were about to make an early morning jump. The plane cleared a 90-foot power line on takeoff, then sharply veered left before crashing

and exploding in a hay field adjacent to the end of the runway. The National Transportation Safety Board determined that pilot error was the probable cause of the crash.

September 14, 2000 Wixom (Oakland County) School Bus Accident

A Northville High School bus carrying 34 football players, 14 cheerleaders, and several coaches collided with an automobile. The car's driver was killed and the car's passenger was injured. Ten bus passengers suffered injuries.

October 16, 2000 St. Clair County Passenger Bus Accident

A semi-trailer smashed into the rear of a charter bus on Interstate 94 in St. Clair County, injuring 44 senior citizens aboard (three critically).

December 17, 2000 Battle Creek (Calhoun County) Passenger Train Accident

An Amtrak passenger train with 161 passengers partially derailed near the train station in Battle Creek, forcing the closure of the railroad tracks in both directions for an extended period of time. The train, composed of a locomotive and five coach cars, was traveling at a low rate of speed when the locomotive and first coach car ran off the tracks a half mile east of the Battle Creek station. The entire train remained upright and the derailed cars were lifted by crane back onto the track. No injuries were reported.

January 21, 2002 Muskegon County School Bus Accident

One person was killed and nearly two dozen high school students were injured when a school bus collided with two cars. About 22 persons were taken to area hospitals with injuries.

October 10, 2002 Monroe County School Bus Accident

A school bus on a field trip was carrying 43 children and 17 adults, and pulled in front of a steel-hauling truck, causing a major collision. Almost all of the passengers were sent to a nearby hospital. Five children were reported to be in critical condition.

June 13, 2003 Detroit (Wayne County) City Bus Accident

At least 20 people were injured when a car ran a red light and crashed into a city bus. Fortunately, none of the people who were transported to local hospitals sustained life-threatening injuries.

August 15, 2006 Kincheloe (Chippewa County) Passenger Airplane Crash

In August 2006, a plane crash occurred outside the Chippewa Correctional Facility in Kincheloe, resulting in four fatalities. Federal officials say that pilot error caused the twin-engine plane to crash. This incident is more significant than many similar small airplane crashes due to the fact that it had hit the outer perimeter fence of the Chippewa Correctional Facility. Had the crash been closer to the facility, the magnitude of its effects would have been much greater.

June 4, 2007 Lake Michigan Passenger Airplane Crash

An unfortunate incident occurred when a plane carrying a team of surgeons and technicians from Milwaukee to Ann Arbor crashed into Lake Michigan. All six passengers died in the incident, including the two pilots, two University of Michigan surgeons, and two technicians due to prepare an organ for transplant surgery at the University of Michigan Health System hospital in Ann Arbor that same afternoon. The National Transportation Safety Board said that one of the pilots had reported severe difficulty steering the plane because of trouble with its trim system, which controls bank and pitch.

August 16, 2008 Grayling (Crawford County) School Bus Accident

A school bus accident occurred while taking kindergartners and preschoolers to a field trip, resulting in 12 injuries. The driver was going too fast, crossed to the other side of the road, and smashed into a pickup truck, injuring both drivers.

October 9, 2008 Washtenaw County Passenger Bus Accident

On the afternoon of October 9, 2008, an accident on highway US-23 occurred when a tractor-trailer crashed into an overloaded bus carrying members of an Amish church, sending 14 of the 21 total passengers, including a number of children, to a hospital in nearby Ann Arbor. Six passengers from the bus that had tipped over on its side were considered to be in serious condition.

February 6, 2009 Grand Rapids (Kent County) Passenger Bus Accident

A school bus carrying about 40 students in Grand Rapids collided with a car, resulting in 16 injures.

February 16, 2009 Detroit (Wayne County) Passenger Bus Accident

Fifteen people were injured when a van drove through a stop sign and crashed into a Detroit Department of Transportation bus on Detroit's West side.

March 1, 2010 Detroit (Wayne County) Passenger Train Accident

On March 1, 2010, a Chicago-bound Amtrak train, with 76 people aboard, struck a Detroit fire truck that had stopped on the tracks in southwest Detroit. The fire truck was responding to a previous crash involving a car and a semi truck. Several passengers sought treatment for minor injuries like head and back pain, and there was $600,000 damage to the ladder truck.

February 7, 2011 Detroit (Wayne County) Passenger Bus Accident

Eleven people were injured when a Detroit City bus crashed into a mail truck in Detroit.

March 24, 2011 Detroit (Wayne County) Passenger Bus Accident

A Detroit Department of Transportation bus hit a car, then slammed into a building in Detroit, resulting in 13 injuries.

January 31, 2013 – Detroit (Wayne County)

A 30-vehicle accident occurred on southbound I-75, resulting in 3 deaths and more than a dozen injuries. Blinding snow, strong winds, and slick road conditions had made driving hazardous. The involved vehicles included multiple semi-trucks as well as numerous passenger vehicles.

August 1, 2013 – Charleston Township (Kalamazoo County)

On westbound I-94 in Charleston Township, a semi truck collided with a Greyhound bus that was carrying 48 passengers. A total of 22 persons were injured, including one front-seat passenger (who was in serious condition) and the driver (who was also hospitalized). Fortunately, most of these injuries were minor.

February 21, 2014 – Isabella County

Because of winter storm whiteout conditions, a jackknifed semi truck and multiple vehicle accidents caused the U.S. 127 highway to close down in both directions, from the Gratiot/Isabella county line to the interchanges south of Mt. Pleasant.

Top 10 Worst Aviation Disasters in the United States

Fatalities	Date	Location	Carrier	Type
2740*	9/11/2001	New York, New York	American / United Airlines	B767 / B767
273	5/25/1979	Chicago, Illinois	American Airlines	B747
265	11/12/2001	Belle Harbor, Queens, New York	American Airlines	A300
230	7/17/1996	off of East Moriches, New York	Trans World Airlines	B747
217	10/31/1999	off of Nantucket, Massachusetts	Egypt Air	B767
189	9/11/2001	Arlington, Virginia	American Airlines	B757
156	**8/16/1987**	**Romulus, Michigan**	**Northwest Airlines**	**MD82**
153	7/09/1982	Kenner, Louisiana	Pan American World	B727
144	9/25/1978	San Diego, California	Pacific Southwest / Private	B727 / C172
135	8/02/1985	Fort Worth-Dallas, Texas	Delta Air Lines	L1011

*Two separate planes hit the World Trade Center, minutes apart. The total number of fatalities includes passengers and crew on both planes, and those killed in the buildings and on the ground.
Source: Planecrashinfo.com

Train Accidents and Vehicle–Rail Crashes in Michigan: 1990-2009

Year	Vehicle-Rail Crashes	Fatalities
1990	203	N/A
1991	176	N/A
1992	153	N/A
1993	133	N/A
1994	147	N/A
1995	121	N/A
1996	119	N/A
1997	124	N/A
1998	90	N/A
1999	110	N/A
2000	125	N/A
2001	97	9
2002	89	7
2003	104	7
2004	89	9
2005	67	4
2006	57	6
2007	61	3
2008	54	4
2009	44	10

The 2009 total of 44 vehicle-train crashes marked a decrease of 64.8 percent over the preceding 10 year period.

Michigan Great Lakes Ship Accidents

Due to the large size of the Great Lakes, there have been many shipwrecks during Michigan's history. The lakes are prone to sudden and severe storms, especially from late October to early December, resulting in hundreds of ships having met their end on the lakes. Reefs are also a common cause of shipwreck disasters. The greatest concentration of shipwrecks in Michigan lies near Thunder Bay, on Lake Huron, near the point where eastbound and westbound shipping lanes converge. Also, on Lake Superior, the vicinity of Whitefish Point became known as the "Graveyard of the Great Lakes" because more vessels have been lost in there than in any other part of Lake Superior. The Whitefish Point Underwater Preserve serves to protect the many shipwrecks in the area. The Great Lakes Shipwreck Museum uses the approximate figures of 6,000 ships and 30,000 lives lost. There are a total of 12 protected underwater preserves in the State of Michigan Great Lakes areas, with a total surface area of over 2,400 square miles. The Michigan Underwater Preserve Council oversees activities relating to all of Michigan's Underwater Preserves. Michigan's Underwater Preserves are considered to be "underwater museums" and protect concentrations of shipwrecks, unique geologic features, and other submerged sites through public awareness and interest. The program does not currently receive any funding from the State of Michigan and does not offer any extra legal protection for the sites in the preserves. However, it is a felony to remove or disturb underwater artifacts in the Great Lakes.

Michigan's Underwater Ship Preserves

Source: Wikipedia online encyclopedia

The number of shipwrecks occurring in the Great Lakes has decreased dramatically from the 1800s to around the 1930s. Not only have travelers tended to favor other means of transportation in recent years, but the decrease in marine accidents can be credited to better weather prediction and communication abilities, radar technologies, and improved ship designs and construction quality. The most recent significant accident occurred with the sinking of the Edmund Fitzgerald in 1975. The U.S. Coast Guard and Canadian Coast Guard maintain stations around the Great Lakes. To prevent fatal accidents in the Great Lakes, lighthouses, ship lighting, shipping regulations, floating navigation aids, and LORAN stations have been implemented and enhanced over time. Also, the U.S. Army Corps of Engineers and other agencies maintain the harbors and seaways to limit groundings, through dredging and seawall projects. Below is a table of some of the most significant shipwreck disasters (primarily those with at least 10 known fatalities) occurring in Michigan's portion of the Great Lakes:

Date	Location	Name	Fatalities
November 10, 1835	Mt. Clemens, MI	Bridget	14
November 25, 1839	Little Point Sable, MI	Neptune	18
November 19, 1846	Lake Erie (Pt. Mouillee, MI)	Lexington	13
June 13, 1847	Munising, MI	Merchant	14
November 20, 1847	**Lake Michigan (Sheboygan, WI)**	**Phoenix**	**161+**
September 13, 1848	Lexington, MI	Goliah	18
June 17, 1850	**Lake Erie (near Cleveland, OH)**	**G.P. Griffith**	**250 to 325**
August 20, 1852	**Lake Erie**	**Atlantic**	**150 to 250 (of 600+)**
November 24, 1853	Beaver Island, MI	Robert Willis	10
October 8, 1854	Detroit River	E.K. Collins	23
December 7, 1854	Lake Michigan	Westmoreland	17
August 8, 1855	Lake Michigan	L.M. Hubby	10
April 27, 1856	Port Austin, MI	Northerner	12 (of 142)
September 24, 1856	**Lake MI (Port Washington, WI)**	**Niagara**	**70+ (of 140)**
October 22, 1856	Lake MI (Port Washington, WI)	Toledo	40 to 55
October 30, 1856	Pictured Rocks Lakeshore, MI	Superior	35
November 4, 1856	St. Joseph, MI	John V. Ayer	10
November 26, 1856	Manistee, MI	Cherokee	10

October 19, 1857	Big Sable Point	Reindeer	23
October 24, 1859	Pte. Aux Barques, MI	Troy	23
September 7, 1860	**Winnetka, IL (Lake Michigan)**	**Lady Elgin**	**297 (of 400)**
November 6, 1860	Lake Michigan	Globe	16
November 10, 1861	Port Austin, MI	Keystone State	33
August 9, 1862	Munising, MI	Oriole	12
August 28, 1863	Keweenaw Point, MI	Sunbeam	28
November 11, 1863	Au Sable, MI	Water Witch	28
November 8, 1864	Lake Michigan	Mojave	10
August 9, 1865	**Thunder Bay, MI**	**Pewabic**	**75 to 100**
April 9, 1868	**Lake Michigan (Waukegan, WI)**	**Seabird**	**102**
September 8, 1868	St. Joseph, MI	Hippocampus	26
September 16, 1868	Lake Huron	Persian	10
November 5, 1869	Lake Huron	J.B. Martin	10
November 15, 1869	Lake Superior	W.W. Arnold	11
November 17, 1869	Straits of Mackinac	Robert Burns	10
September 22, 1871	Lake Michigan	Charles H Hurd	11
October 15, 1871	Pte. Aux Barques, MI	R.G. Coburn	32
September 15, 1873	Grand Haven, MI	Ironsides	20
December 4, 1873	Saginaw Bay	City of Detroit	20
October 22, 1874	Wyandotte, MI	Brooklyn	22
August 26, 1875	Whitefish Bay	Comet	11
September 10, 1875	Lake Michigan	Equinox	25
September 10, 1875	Lake Michigan	Mendota	12
July 9, 1876	Ontonagon, MI	St. Clair	26
November 22, 1879	Lake Huron	Waubuno	22
August 29, 1880	Alcona, MI	Marine City	9 to 20 (of 158)
October 15, 1880	**Lake Michigan**	**SS Alpena**	**100+**
November 24, 1880	Lake Huron	Simcoe	13
September 10, 1881	Frankfort, MI	Columbia	16
November 26, 1881	Lake Huron	Jane Miller	30
May 18, 1882	Lake Huron	Manitoulin	11 to 25
September 14, 1882	Lake Huron	Asia	123
December 1, 1882	Lake Michigan	R. G. Peters	14
May 20, 1883	Lake Michigan	Wells Burt	10
November 16, 1883	Lake Superior	Manistee	23
December 14, 1883	Lake Superior	Mary Ann Hulbert	20
May 24, 1881	**Thames River**	**Victoria**	**181 (of 600)**
November 7, 1885	Isle Royle	Algoma	37
June 16, 1887	Charlevoix, MI	Champlain	22
October 25, 1887	Lake Michigan	Vernon	36 to 41
August 30, 1892	Deer Park, MI	Western Reserve	26
October 1, 1892	Lake Michigan	W.H. Gilcher	21
October 4, 1892	Lake Huron	Nashua	15
November 7, 1893	Pte. Aux Barques, MI	Philadelphia	16 to 24
January 21, 1895	St Joseph, MI	Chicora	25
October 9, 1895	Lake Huron	Africa	13
October 24, 1898	Lake Michigan	L.R. Doty	17
May 24, 1901	Au Sable, MI	Baltimore	13
September 16, 1901	Eagle River, MI	Hudson	25
November 22, 1902	Lake Superior	Bannockburn	21
October 3, 1903	Menominee, MI	Erie L Hackley	11
September 2, 1905	Keweenaw, MI	Iosco	19
October 20, 1905	Lake Huron	Kaliyuga	17
November 22, 1906	Lake Huron	J.H. Jones	26
April 12, 1907	Big Sable Point	Arcadia	14

October 11, 1907	Deer Park, MI	Cyprus	22
December 1, 1908	Lake Superior	D.M. Clemson	24
May 1, 1909	Whitefish Bay	Adella Shores	18
July 12, 1909	Whitefish Bay	SS John B. Cowle	14
December 8, 1909	Lake Erie	Clarion	15
December 9, 1909	Marine City, MI	Badger State	15
May 23, 1910	Pte. Aux Barques, MI	Frank H. Goodyear	16
September 8, 1910	Lake Michigan	Pere Marquette 18	25
August 21, 1911	Lake Huron	C.C. Martin	10
November 26, 1912	Lake Michigan	Rouse Simmons	17
November 7-11, 1913	**Great Lakes Storm**	**12 ships sank**	**255+**
April 27, 1914	Lake Superior	Benj. Noble	22
November 19, 1914	Grand Marais, MI	C.F. Curtis	14
July 24, 1915	**Chicago River / Lake Michigan**	**SS Eastland**	**844**
May 8, 1916	Eagle Harbor, MI	S.R. Kirby	20
November 24, 1918	Lake Superior	Cerisoles	38
September 22, 1919	Muskegon, MI	City of Muskegon	29
November 13, 1919	Lake Superior	John Owen	23
November 23, 1919	Whitefish Bay	Myron	17
August 20, 1920	Whitefish Bay	SS Superior City	29
October 30, 1921	Lake Michigan	Rosa Bella	11
April 19, 1922	Whitefish Bay	Lambton	22
December 1, 1922	Lake Superior	Maplehurst	11
September 22, 1924	Oscoda, MI	Clifton	27
December 7, 1927	Twelve O'Clock Point, Isle Royale	Kamloops	22
September 15, 1928	Lake Huron	Manasoo	16 (+116 cattle)
September 9, 1929	Holland, MI	Andaste	25
October 22, 1929	Lake Michigan	Milwaukee	52
October 29, 1929	Lake Michigan (off Kenosha, WI)	Wisconsin	18
July 29, 1936	Lake Michigan	Material Service	15
November 11, 1940	Pentwater, MI	SS William B. Davock	33
November 11, 1940	Pentwater, MI	Anna C. Minch	24
September 24, 1942	Lake Huron	Wawinet	25
June 4, 1947	Isle Royale, MI	Emperor	12
September 17, 1949	**Lake Ontario**	**Noronic**	**119**
May 11, 1953	Isle Royale, MI	Henry Steinbrenner	14
November 18, 1958	Lake Michigan	Carl D. Bradley	33
May 7, 1965	Lake Huron	Cedarville	10
November 29, 1966	Lake Huron	SS Daniel J Morrell	28
November 10, 1975	Whitefish Bay	SS Edmund Fitzgerald	29
June 5, 1979	Copper Harbor, MI	Cartiercliffe Hall	7 (most recent)

Sources: http://www.boatnerd.com/swayze/shipwreck/a.htm and http://greatlakeshistory.homestead.com/Alpha.html

Michigan Boating Accident Statistics

Every year, the U.S. Coast Guard compiles statistics on reported recreational boating accidents. These statistics are derived from accident reports that are filed by the owners / operators of recreational vessels involved in accidents. The states, territories, and District of Columbia all submit accident report data to the Coast Guard for inclusion in the annual Boating Statistics publication. Modern boat accidents are common, as the following table shows.

Michigan Boating Accidents

Year	Total Accidents	Total Fatal Accidents	Total Deaths
1995	395	22	29
1996	478	19	20
1997	354	22	22
1998	451	21	25
1999	343	27	28
2000	227	26	31
2001	299	25	28
2002	226	36	37
2003	218	25	29
2004	143	26	27
2005	161	26	28
2006	185	24	30
2007	185	30	34
2008	187	30	34
2009	131	32	36

Michigan Transportation Trends

Michigan uses air, water, highway, and rail as its major means of transporting people and goods. Michigan has seen an increase in all sectors of transportation over the past few decades, except for the marine sector. As traffic in each sector of transportation increases, so does the risk of accidents. The following section describes the transportation trends in Michigan over the past few decades.

Air Traffic

Air traffic has increased significantly in recent years. With many travelers choosing to fly rather than drive, the airways have become more congested. As the following table shows, flying has also become a more popular way to ship cargo and mail. Total air operations in Michigan have increased greatly since 1990, making airways and runways more congested than in the past.

Indicator	1990	1995	2000	% Change (1990-2000)
Control Tower Airport Operations	2,077,400	2,019,389	2,191,931	**+ 5.5%**
Non-Towered Airport Operations	1,934,190	2,235,520	2,517,131	**+ 30.1%**
Total Scheduled Air Carrier Passengers	25,112,384	31,596,208	40,528,139	**+ 61.4%**
Air Cargo, Express and Package Freight (tons)	272,443	353,189	361,023	**+ 32.5%**
Air Carried Mail	78,955	130,322	99,718	**+ 26.3%**
Total Operations (includes all control tower activities)	4, 011,590	4,254,909	4,709,062	**+ 17.4%**

Highway Traffic

Highway travel in Michigan has increased at a far greater rate than the state's population. This increase in travel is attributed to the longer distances traveled to work and other places, and increases in tourism and recreation travel. Although the state highway system comprises only 8% of the Michigan roadway network length, it carries more than 53% of the total statewide traffic. (A map of highways appears at the end of this section.) MDOT traffic summary statistics indicate that I-696 from I-75 to Couzens Avenue was the busiest section of highway in 2001, carrying an average of 219,000 vehicles a day. I-696 actually had six out of the top eight busiest sections in the

state for 2001. Although traffic continues to increase in Michigan, the number of traffic crashes continues to decrease. There were 290,978 total crashes statewide in 2009, a 31.5 percent decrease from the 2000 total of 424,675. More importantly, the total number of fatal crashes has decreased by an even larger percentage. In 2009, there were 806 fatal crashes, down 41.7 percent from 1,382 in 2000.

Total Crashes (Including Total Fatal Crashes and Total Deaths):

Year	Total Crashes	Fatal Crashes	Total Deaths	Year	Total Crashes	Fatal Crashes	Total Deaths
1990	387,180	1,396	1,563	**2000**	424,852	1,237	1,382
1991	364,847	1,290	1,425	**2001**	400,813	1,206	1,328
1992	344,942	1,179	1,300	**2002**	395,515	1,175	1,279
1993	363,636	1,269	1,414	**2003**	391,485	1,172	1,283
1994	398,050	1,262	1,419	**2004**	373,028	1,055	1,159
1995	421,073	1,386	1,537	**2005**	350,838	1,030	1,129
1996	435,477	1,339	1,505	**2006**	315,322	1,002	1,084
1997	425,793	1,283	1,446	**2007**	324,174	987	1,084
1998	403,766	1,235	1,367	**2008**	316,057	915	980
1999	415,675	1,249	1,386	**2009**	290,978	806	871
% Change of Total Crashes (1990-2009) -33%							

Total miles traveled, in billions of miles:

Year	Travel (Billions of Miles)	Year	Travel (Billions of Miles)
1950	22.0	**2000**	94.9
1960	33.1	**2001**	96.5
1970	53.1	**2002**	98.2
1980	61.5	**2003**	100.2
1990	81.2	**2004**	101.8
1995	85.7	**2005**	103.2
1996	87.7	**2006**	104.0
1997	89.2	**2007**	104.6
1998	91.6	**2008**	100.9
1999	93.1	**2009**	95.9
% Change (1990-2009) + 15.3%			

Marine Traffic

The St. Lawrence Seaway and the Great Lakes form a maritime transportation system extending more than 2,000 miles from the Gulf of St. Lawrence on the Atlantic Ocean to the western end of Lake Superior. Michigan has roughly 3,200 miles of shoreline and more than 100 ports serving commercial and recreational navigation. (See the map at the end of this section.) There are also 20 routes of ferry service in Michigan's waterways. Michigan has seen a steady increase in air, rail, and highway transportation over the past few decades, but marine transportation has remained relatively constant. Marine commerce has actually seen a decrease since the 1960s and 1970s, although it has begun to pick up again and has had a 10 percent increase since 1990. Most of Michigan's waterborne traffic is generated by the steel and construction industries and is susceptible to variations in the general economy and the effects of restructuring in the steel industry.

Marine Shipping (Tonnage)

Year	Tonnage	Year	Tonnage
1960	99,684,998	**1981**	75,685,806
1961	88,815,641	**1982**	51,312,257
1962	90,959,374	**1983**	62,416,537
1963	97,730,256	**1984**	75,067,451
1964	109,139,474	**1985**	71,981,889
1965	107,500,170	**1986**	72,527,695
1966	113,716,689	**1987**	79,430,130
1967	110,767,016	**1988**	88,243,048
1968	108,668,893	**1989**	91,459,033
1969	109,328,660	**1990**	85,765,857
1970	110,397,756	**1991**	78,952,003
1971	103,879,534	**1992**	84,622,726
1972	103,555,651	**1993**	87,701,134
1973	106,598,408	**1994**	93,990,253
1974	101,393,927	**1995**	93,610,750
1975	91,411,396	**1996**	93,613,000
1976	97,380,680	**1997**	98,673,521
1977	92,834,512	**1998**	101,306,079
1978	101,788,264	**1999**	96,493,819
1979	102,225,008	**2000**	94,285,388
1980	82,409,928	**% Change (1990-2000) + 10%**	

Railroads (Entire U.S.)

Freight railroads are critical to the economic well-being and global competitiveness of the United States. They move 42% of the nation's freight and connect businesses with each other across the country and with markets overseas. The United States has seen recent increases in railroad cargo weight. Increased railroad traffic and cargo weight may increase the risk of railway accidents, especially highway/rail incidents. Passenger railroad traffic has also been increasing recently, encouraged by higher fuel prices and increasing congestion within other types of transportation networks.

Year	TOFC / COFC Loadings (in millions of units)
1990	6
1995	7.8
2000	9
% Change (1990-2000) + 50%	

Programs and Initiatives

Air Transportation

The Michigan Aeronautics Commission of the MDOT administers several programs aimed at improving aviation safety and promoting airport development. The Commission's safety programs include: (1) registering aircraft dealers, aircraft, and engine manufacturers, (2) licensing airports and flight schools, (3) inspecting surfaces and markings on airport runways, and (4) assisting in the removal of airspace hazards at airports. The Commission's airport development program includes the provision of state funds for airport development and airport capital improvements, many of which contribute to overall air transportation safety.

The Federal Aviation Administration (FAA) contracts with the MDOT for the inspection of the state's 238 public-use airports on an annual basis. The FAA has regulatory jurisdiction over operational safety and aircraft

worthiness. The National Transportation Safety Board (NTSB) investigates all aircraft crashes that involve a fatality, and regularly publishes reports on its findings (see the NTSB section below).

Local plane crash concerns may already have been analyzed by community airports or planners, in accordance with the Airport Zoning Act of 1950:
(see http://www.michiganlegislature.org/documents/mcl/pdf/mcl-act-23-of-1950-ex-sess..pdf).

Land Transportation

Bus Safety

School bus safety programs and initiatives generally fall into two categories: (1) driver skill enhancement and competency training, and (2) physical inspections of buses' mechanical and safety equipment. All school bus drivers in Michigan must pass a bus driver education and training program, and then take regular refresher courses to maintain their certification to operate a school bus. School bus drivers must also pass an annual medical examination.

Local transit and intercity bus safety falls under the purview of the Michigan Department of Transportation (MDOT). Generally, the issue of intercity and transit bus safety is handled on a partnership basis with service providers, with MDOT providing oversight of the initiatives undertaken by the providers to ensure mechanical and operational safety.

Railroad Safety

The MDOT is the state regulatory agency for railroad-highway at-grade crossing safety issues. In this role, MDOT conducts biennial, on-site crossing reviews for Michigan's 5,535 public crossings, and reports observed crossing maintenance deficiencies to the responsible railroad or roadway authority. In addition, MDOT conducts diagnostic study team reviews at selected crossings to determine whether the current level of warning device requires enhancement. At the present time, 42% of Michigan's public crossings at least have automatic side-of-street flashing light signals, and 16% have automatic gates.

In January 2001, an amendment (2000 PA 367) to the Michigan Vehicle Code went into effect, allowing the MSP, MDOT, or specified local officials to install video cameras at railroad crossings to serve as a deterrent to motorists who might attempt to go around or through activated railroad crossing lights and gates. Although the ultimate purpose of this law is to reduce pedestrian and vehicular deaths and injuries at railroad crossings, the law will also likely reduce passenger train accidents caused by collisions with vehicles on the tracks, which is a major cause of many passenger train derailments.

Michigan's "Operation Lifesaver" Coalition—part of a national, non-profit education and awareness program dedicated to ending tragic collisions, fatalities and injuries at highway-rail at-grade crossings and on railroad rights of way—has helped reduce the number of serious crashes at railroad crossings in the state. The Operation Lifesaver coalition in Michigan is spearheaded by the MSP and MDOT and is composed of state and local government officials, law enforcement, and employees of the railroad companies operating in Michigan. The Operation Lifesaver program emphasizes education and enforcement, and its efforts appear to be working. Since 1996, the number of crashes, injuries, and fatalities at railroad crossings in Michigan has shown a steady decline. Any reduction in vehicle-train crashes at railroad crossings helps reduce the likelihood of a passenger transportation accident involving buses and trucks. Another MDOT program that can help to improve rail safety is the Michigan Rail Loan Assistance Program. Established under Act 1997 PA 117, this program was initiated to help finance capital improvements on Michigan's rail infrastructure. Although the program is designed primarily to help preserve and improve rail freight service, any improvements made to a portion of rail infrastructure that also serves passenger rail service can only help to improve passenger rail safety. Track rehabilitation is one of the eligible projects that can be funded under this program, and the safety value of a project is one of the primary selection criteria.

Water Transportation

All marine passenger ferries operating on the Great Lakes must pass regular inspections by the U.S. Coast Guard, for vessel safety and worthiness. In addition, all personnel operating marine passenger ferries must be trained to Coast Guard standards and meet annual certification requirements. Passenger ferries are equipped with individual life preservers and other rescue gear on board, in addition to having marine radios to request help should the need arise. Prior to departure, all passengers using ferry services are given brief instructions on what to do should the vessel somehow become disabled to such a degree that it is in danger of sinking.

Fortunately, Michigan has not suffered a significant water transportation accident involving a marine passenger ferry. Even with this unblemished safety record, the potential always exists for a serious water transportation accident to occur on the Great Lakes. Such an event would have the potential to be a significant mass casualty incident and possibly require a massive water rescue and recovery effort.

National Transportation Safety Board

The National Transportation Safety Board is an independent federal agency responsible for promoting aviation, highway, railroad, marine, pipeline, and hazardous materials transportation safety. The NTSB is mandated to investigate significant transportation accidents, determine the probable cause of such accidents, issue safety recommendations, study transportation safety issues, and evaluate the safety effectiveness of government agencies that are involved in transportation. The NTSB makes public its actions and decisions through accident reports, safety studies, special investigation reports, safety recommendations, and statistical reviews. Although the NTSB has no regulatory or enforcement powers, it has nonetheless been successful in seeing the adoption and implementation of over 80% of its transportation accident recommendations.

An example of an NTSB recommendation being implemented is the agreement between the FAA and the Boeing Aircraft Company to redesign the rudder system on the company's popular 737 jetliners and to replace the rudder valve system in every one of the 737 jets in service. The rudder retrofit program cost Boeing nearly one-quarter of a billion dollars. (The 737 rudder system came under the close scrutiny of the NTSB after crashes of 737s in 1991 and 1994 had resulted in over 150 deaths. The NTSB believed that the rudder system on the two jets might have been a contributing factor in the crashes.)

Final Rule on the Reflectorization of Rail Freight Rolling Stock

The Final Rule requires railroads and other companies owning rail cars to install yellow or white reflective materials on locomotives over a five-year timeframe, and on freight trail cars over a 10-year period. The reflective materials are to be installed on all newly constructed locomotives and freight rail cars, and on existing ones during periodic maintenance repair, unless alternate implementation plans have been developed that meet the deadlines. Nearly one quarter of all highway-rail crossing collisions involve motor vehicles running into trains occupying at-grade crossings. This new rule is the most recent effort by the Federal Railroad Administration (FRA) to increase the visibility of trains at highway-rail at-grade crossings.

Airport Zoning Act of 1950

Plane crash concerns may already have been analyzed by an area's airports or planners, in accordance with the Airport Zoning Act of 1950. Please refer to http://www.legislature.mi.gov/documents/mcl/pdf/mcl-act-23-of-1950-ex-sess-.pdf for more details.

Hazard Mitigation Alternatives for Major Transportation Accidents

- Improved design, routing, and traffic control at problem roadway areas.
- Railroad inspections and improved designs at problem railway/roadway intersections (at grade crossings, rural signs/signals for RR crossing).
- Long-term planning that provides more connector roads for reduced congestion of arterial roads.

- Use of designated truck routes.
- Use of ITS (intelligent transportation systems) technology.
- Airport maintenance, security, and safety programs.

Tie-in with Local Hazard Mitigation Planning

Because many means of implementing mitigation actions occur through local activities, this updated MHMP places additional emphasis on the coordination of State-level planning and initiatives with those taking place at the local level. This takes two forms:

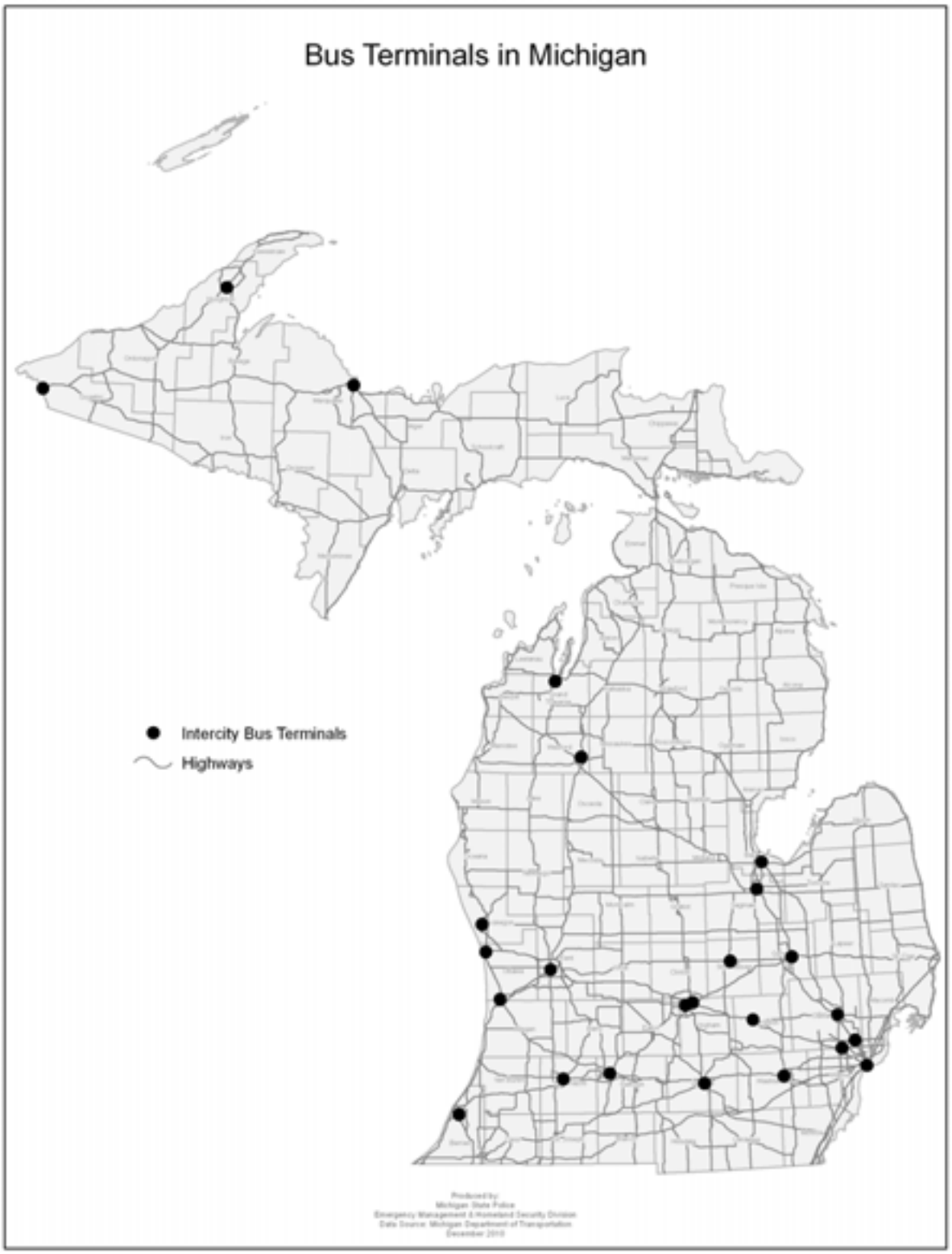
1. The provision of guidance, encouragement, and incentives to local governments by the State, to promote local plan development, and
2. The consideration of information contained in local hazard mitigation plans when developing State plans and mitigation priorities.

Regarding the first type of State-local planning coordination, MSP guidance has included the "Local Hazard Mitigation Planning Workbook" (EMD-PUB 207), which is currently being updated for release by 2015. For the second type of State-local planning coordination, a section later in this plan summarizes hazard priority information as it has been reported in local hazard mitigation plans. Here, it will merely be noted that transportation accidents were identified as one of the most significant hazards in the local hazard mitigation plan for Huron County.

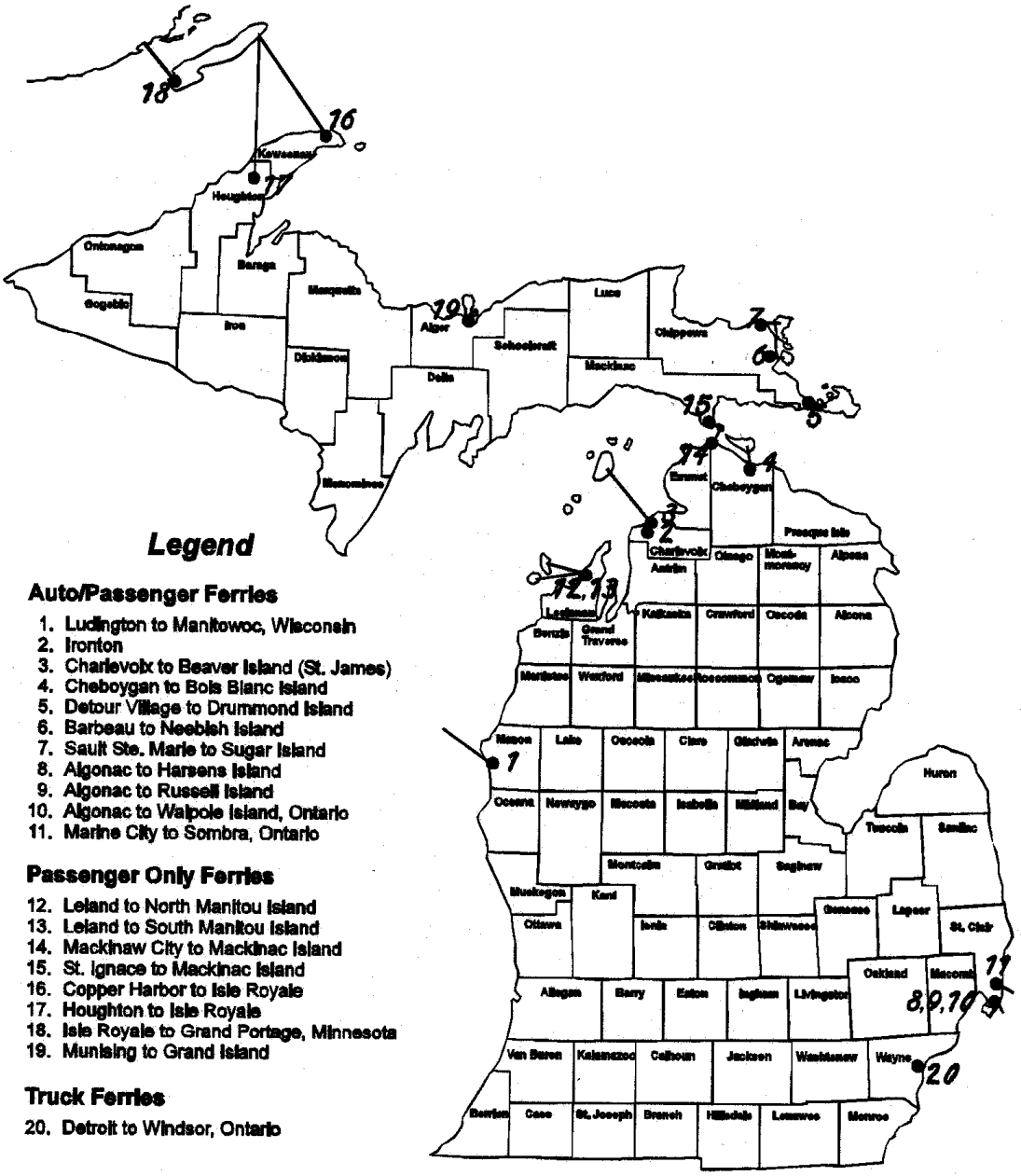
Michigan's Airports

Michigan Intercity Rail Passenger Transportation System

Michigan Intercity Bus Passenger Transportation System



Michigan Marine Passenger Transportation System



Source: MDOT, Bureau of Transportation Planning, Travel Demand & Intermodal Services Section, Modal Services Unit

Principal Ports in Michigan

III. HUMAN-RELATED HAZARDS

The following list summarizes the significant human-related hazards covered in this section:

1. Catastrophic Incidents (National Emergencies)
2. Civil Disturbances
3. Nuclear Attack
4. Public Health Emergencies
5. Terrorism and Similar Criminal Activities

These hazards all tie in with each other in various ways, and by placing them all in the same section of this document, this updated 2014 edition of the Michigan Hazard Mitigation Plan intends to make it easier for planners and emergency management personnel to learn about and consider the many aspects of these threats, risks, activities, conditions, and incidents.

The new hazard section, Catastrophic Incidents (National Emergencies), was primarily inspired by some of the states of alert and response activities that Michigan had to adopt in the past decade for incidents that primarily took place outside of its own borders. The main examples were the 9/11/2001 terrorist attacks (and subsequent anthrax incidents and threats), and the Gulf Coast disaster involving Hurricanes Katrina and Rita in 2005. It makes sense to consider, in advance, these types of incidents as well as other types of large-scale disasters that could occur in the future, which require a large-scale national response even though the actual incident itself may occur only within the borders of a few states outside of Michigan's immediate environment. Preparedness, planning, exercising, and mutual aid arrangements are the main "mitigation" activities proposed for this hazard during its initial phase of consideration in this 2014 edition of the Michigan Hazard Mitigation Plan. Some catastrophic incidents may involve other types of human-related hazards. Some of the possibilities that led to the addition of this hazard as a new section include recent considerations of a major pandemic, terrorist attack, or nuclear strike—all of which are covered in more detail in subsections herein.

Although civil disturbances are usually handled at the level of local or state governments alone, some types of unrest may be related to broader patterns of criminal activities, or even terrorism. The civil disturbance hazard has been given broader treatment, to shift farther beyond the emphasis on prisons that had been a part of its original concept in earlier state planning documents. Although prison disturbances are still considered a hazard, several additional types of incident have been more extensively discussed and compared. Although consideration was given to a type of civil disturbance that could be called "disruption," it was decided that such a concept was already partially covered by the discussion of catastrophic incidents and other hazards. "Disruption" would have described human collective responses to large-scale catastrophes, such as warfare, widespread conflict, or disasters, that disrupt ordinary lifestyles and force people to cope using relatively spontaneous or grassroots activities to provide for social needs. There were few examples that were clearly relevant to today's contemporary circumstances, however, except for those already suggested in other sections, and so the idea was not included as a full consideration within this edition. Consideration was also given to economic and criminal problems, but these were not considered relevant enough to an emergency management planning perspective to include. Emergency management deals with recognized disasters and emergency events, rather than social problems more broadly, and therefore throughout this plan decisions had to be made about where the line might be drawn between specific disaster/emergency events and circumstances that are ongoing social, economic, political, and environmental issues in any society.

Although warfare and other types of conventional military attack were not given specific treatment here, the nuclear attack hazard has been retained, yet almost entirely rewritten to reflect post-Cold War geopolitical circumstances. In addition, a greater connection is now exhibited between the nuclear attack hazard and that of terrorism. Public health emergencies have taken on new importance recently, with the rise in concern about

global pandemic illnesses. Travel is so rapid and widespread today that quickly detecting and containing outbreaks of serious, even lethal, contagious diseases has been considered necessary and given higher priority by numerous levels of government, and their partnering agencies. Terrorism is one of the potential causes of widespread threats to public health, as well as nuclear attack and certain types of civil disturbances. The terrorism and similar criminal activities section has also been almost entirely rewritten in this 2012 edition of the Michigan Hazard Analysis, to reflect more recent knowledge about the involved topics. In many cases, it may not be immediately clear whether an incident was motivated by political causes, some other form of protest, criminal enterprises, or personal neurosis. A bomb blast event, for example, may have its origin in a hostile terrorist group, a riotous uprising, a murderous act involving organized crime, or the misguided activity of a mentally unbalanced individual. The act itself, and its effects, might constitute an emergency event regardless of the reasons that caused it to happen. In many cases, the determination of who organized such a bombing, and why, may take weeks of subsequent investigation, and may place the event (after the fact) within different hazard classifications, as they have been presented here. For that reason, it is recommended that the human-related hazards be studied together. At the very least, the civil disturbances and terrorism sections should be studied together, and those who are interested in terrorism should also give consideration to the nuclear attack and public health emergencies that can be caused by terrorist attacks.

During certain historical times and places, it might seem to make sense to include large-scale or widespread criminal activities as a type of hazard in itself. Gang warfare can certainly impose a serious toll upon the health and safety of an area, for example, and such enterprises may be used to raise funds for international terrorist activities. At this time, however, it was decided not to include large-scale organized crime as a specific type of hazard in this analysis, except where the purpose of that crime relates to terrorist activities (rather than the profit-oriented activities that are typical of criminal enterprises). Organized crime exists to try to make its participants wealthy, but terrorism aims to cause specifically destructive effects upon society—usually without any expectation or desire for personal profit or wealth or the part of the perpetrator(s). Dedicated law enforcement resources already exist specifically to combat crime of various types, and these ongoing activities usually do not involve emergency management personnel, declarations of disaster, or the type of public involvement and planning used for the mitigation of natural disasters and other-types of potentially large-scale hazards.

Overlap Between Human-Related Hazards and Other Sections of the Hazard Analysis

Terrorist and nuclear attack events can cause widespread infrastructure failures, hazardous materials incidents, transportation accidents, energy emergencies, nuclear power plant emergencies, structural fires, and oil/gas pipeline failures. Therefore, there is extensive overlap with the Technological Hazard sections. It is also possible that terrorist and nuclear attack events may cause dam failures and flooding, as well as wildfire events—two of the hazards that are addressed in Natural Hazards sections in this document.

In a reverse direction of causality, various natural and technological hazards may be expected to cause significant public health concerns. These include weather hazards such as extreme temperatures, hydrological hazards such as flooding and drought (both of which may affect the quality of drinking water in an area, as well as exacerbate the risks of contagious illness and food quality/contamination), and the ecological hazard of wildfires. Any disaster that can cause widespread homelessness and power failures may have a serious impact upon public health. Similarly, various types of incidents involving hazardous materials (including radiological incidents) may affect public health. Disasters with an extensive impact upon the environment may involve contamination that is a threat to public health.

With regard to natural or technological events that may cause violent incidents, the most probable circumstances may involve civil disturbances in reaction to other emergency or disaster circumstances, if overwhelming to or poorly handled by responders or government agencies. There are very few historical records of such incidents escalating to the point of a civil disturbance emergency in Michigan, and even then, the connection between natural and technological hazards and such disturbances has tended to be indirect and open to alternative interpretations. Most civil disturbance events have been rooted in other human circumstances. One of the

exceptions involves the potential for widespread infrastructure failures to develop into circumstances in which local citizens and police must take extra precautions against criminal activity such as looting. With a large enough event or over a long period of time, such conflicts may cause certain types of civil disturbances to occur. Another important scenario involves the handling of prisoners in correctional facilities, during incidents of any cause that may require the area's evacuation, or special in-place sheltering (as from a tornado or a severe hazardous materials incident). It is important for correctional facilities to have planned for how their institutions could handle such emergency events—providing an appropriate level of protection for the incarcerated while also maintaining the needed level of order, control, and surveillance over them.

CATASTROPHIC INCIDENTS
(National Emergencies)

A large-scale event that has severe effects upon large numbers of persons, across a wide area, and immediately overwhelms State, tribal, and local response capabilities. Such incidents are likely to require coordination activities from many states, including Michigan, even if the event took place in a distant location.

Introduction

Since 2000, the nation has been affected by disastrous events that have caused various states, including Michigan, to undertake significant actions to respond to, assist, or help accommodate the impact of events that took place well outside of their borders. Mutual aid agreements are in place between states to provide one another with supplemental resources and capabilities to respond to and recover from a disastrous event. It is also possible that certain types of events outside of U.S. territory may require coordinated response, as well.

The National Response Framework (aka Federal Response Plan) involves a recognition of, and reaction to, events of national significance. This was observed during the terrorist events of September 11, 2001—along with the federal government, all states went into a mode of heightened alert and exchanged various information and resources in a coordinated manner. More recently, Hurricanes Katrina and Rita caused such disruption in the southern states that nation-wide assistance and coordination was needed. Not only were resources deployed to the disaster areas themselves, but distant states such as Michigan also needed to accommodate large numbers of evacuees who were temporarily displaced from their homes, jobs, businesses, and even families. Some evacuees even chose to permanently change their residence to new homes in other communities across the U.S.

In some disaster scenarios, even if Michigan experiences some direct impacts, it may turn out that much greater effects in other states or nations (e.g. Canada) may require extensive additional actions to be taken by Michigan government and personnel. In recognition of these extra tasks, a Catastrophic Incident hazard is now identified, in addition to the many hazards that are known to potentially have a direct impact within Michigan.

FEMA has (in its Catastrophic Incident Annex of November 2008) defined the nature of the catastrophic disaster situation. It "will result in large numbers of casualties and/or displaced persons, possibly in the tens to hundreds of thousands…. The nature and scope of a catastrophic incident will immediately overwhelm State, tribal, and local response capabilities and require immediate Federal support…. A catastrophic incident will have significant international dimensions, including impacts on the health and welfare of border community populations, cross-border trade, transit, law enforcement coordination, and others."

Special aspects that may be part of catastrophic incidents include the possibility of occurrence without warning, the occurrence of multiple incidents over a wide-ranging area (or even without any clearly defined incident site), may involve large-scale evacuations (whether organized or self-directed), may cause widespread homelessness and displacement (either temporary or permanent), may overwhelm existing health-care systems, and may produce severe environmental impacts that exceed governmental abilities to achieve a timely recovery.

Catastrophic Incident Scenarios

There are a great many possible situations that can result in nationwide activation of mutual aid and other response and recovery mechanisms, so it is not intended that this section will provide an exhaustive list of everything that may happen. This subsection does, however, provide about ten "scenarios" designed to suggest the types of situations that may be considered a catastrophic incident. It is hoped that this will assist planners and responders in further developing their mutual aid arrangements at all levels, to accommodate a wider variety of needs, and to suggest some possible repercussions that may not have previously been considered in existing planning and exercise scenarios.

Major Hazardous Materials Incidents
An event of sufficient magnitude (like the Chernobyl nuclear power plant disaster or Bhopal hazardous materials release) may warrant a response even if located in another country. A good example for Michigan could involve a major "Chemical Valley" incident in Sarnia, Ontario. It has been reported that this one industrial area (located just across the St. Clair River from the City of Port Huron) involves 40% of Canada's chemicals, including the largest liquid natural gas storage facility in North America. Canada has national, provincial, and local regulatory frameworks that have allowed the "Chemical Valley" area to function effectively for many years, but if some sort of unlikely circumstance or deliberate terrorist activity causes a major problem in the area, its potential impacts could be great.

Energy Emergencies and "Great Blackouts"
Michigan does not need to be directly involved in a major event for it to have significant consequences that warrant the provision of State-level assistance or response. One of the most notable scenarios involves the possibility of an energy emergency. It has been reported that 28 pipelines run between the cities of Port Huron, MI and Sarnia, Ontario. These pipelines reportedly support 85% of the heating that Michigan and Ontario residents require to maintain a normal and productive lifestyle. Serious disruptions in energy supply (along with higher costs for available product) may result from a disaster that disrupts these supply lines. Such a circumstance would not need to occur specifically in Michigan in order to cause serious problems here.

The loss of electrical power for a long enough time would be expected to cause a certain proportion of affected persons to undergo serious hardships—particularly those who have special medical needs or disabilities. Shortages of certain types of goods or services may affect Michigan, even if the blackout itself is not directly experienced here. Similarly, gaps in communication, information, or service networks may have an effect well beyond the actual area that lacks electrical power.

A "Supervolcano" Event
A volcanic eruption of sufficient size could cause an incident of national significance. In 1980, the eruption of Mount St. Helens (in the State of Washington) caused about 540 million tons of volcanic ash to be scattered over an area of some 22,000 square miles. A massive eruption of a "supervolcano" would cause a much larger area of destruction and emit billions of tons of ash into the air. Some locations have been identified in the western United States where this type of event is possible (e.g. Yellowstone National Park – see USGS information at http://volcanoes.usgs.gov/observatories/yvo/), even if not expected in the near or medium term—three events during the past 2.1 million years. It has been calculated that volcanic ash from a "supervolcano" event could be transported through the atmosphere over a much broader area, and that significant quantities could be carried and deposited as far away as Michigan. The size of such an eruption itself would likely be considered to be a catastrophic incident and thus would probably warrant a Michigan response in providing assistance to the more heavily involved western states. The USGS maintains a Volcano Alert System, with color codes (green, yellow, orange, red) to indicate alert levels for a particular volcano. The Yellowstone Caldera is currently classified as green (normal). The largest eruption in recorded history was that of Mount Tambora (Indonesia), in 1815, which led 1816 to be called "the year without a summer" and led to food shortages worldwide. Previously, the most comparable event was probably an eruption at Mt. Mazama, Oregon—seven thousand years ago!

Warfare
Military action has the potential to create a catastrophic incident. The United States is potentially vulnerable to attacks on its own territory, including attacks by military nuclear weapons. Furthermore, war in other parts of the world could have significant impacts on Michigan due to economic repercussions and potentially serious drains on Federal government resources. Because of the interconnectedness of international trade, finance, and communications, harmful effects might be felt from wars fought in distant places. Michigan also is home to an ethnically diverse population and foreign wars tend to directly impact on the homelands and families of these citizens. Even in cases when major warfare does not involve direct attacks against United States territory, some form of general mobilization may require a reorganization of production and consumption patterns throughout the

country—patterns which have historically involved a temporary increase in government control. During the period of the Cold War arms race, the impacts of warfare upon the United States may have seemed like it would have "all or nothing" character, in which the mainland would either remain untouched or it would be subjected to devastating and widespread nuclear strikes. Today, additional possibilities appear to be more likely. Possibilities include a series of terrorist strikes by non-state actors, the use of missile technology by hostile states, or destructive acts of cyber-sabotage from sources that may be difficult to identify.

Major Terrorist Attack

Major terrorist attacks could create a catastrophic incident, particularly if those attacks use weapons of mass destruction or are targeted on critical national infrastructure. Large-scale terrorism may create economic and infrastructure damage similar to military attacks. In addition, terrorists usually choose their targets with the goal of creating as much fear and uncertainty as possible. Dealing with a major terrorist attack will require addressing the concerns of frightened and confused citizens. It is worth noting that the details and limits of a terrorist attack are rarely understood immediately, complicating response efforts. For example, following the 9/11 attacks, confusing reports and uncertainly regarding possible additional targets caused the Federal government to take significant precautionary measures. These included shutting down the national air-travel system and evacuating senior officials. Similar dramatic steps (even if temporary) might be needed in response to future major terrorism events.

Major Earthquakes

Although a major earthquake involving the New Madrid Fault would likely have some effect on the southern portions of Michigan, it is probable that an even greater Michigan effect would stem from the massive damages, casualties, and human needs that would need to be addressed near the earthquake's epicenter (or the earthquakes' epicenters). Another possibility could involve a major earthquake along California's San Andreas Fault line, or at some other at-risk location. If the magnitude of the event is great enough, the incident may rise to the level of a catastrophic incident and thus prompt a significant response by Michigan's government, agencies, and residents.

Celestial Impact

An impact by an asteroid, comet, or meteorite has the potential to be a catastrophic incident if the object has sufficient mass and velocity to cause extensive harm. This may even be true if the impact occurs on the other side of the planet, for there may exist a relationship between celestial impacts and a rise in volcanic and earthquake activity. Approximately once per century, a major impact (over a land mass) has been observed that is of a scale comparable to a nuclear blast. Two such events were seen in Siberia, in 1947 and 1908, and in the Arabian Peninsula, in 1863. The fear is that since the Earth's population is so much greater now, as is the scale of human settlement, it has become more likely that the next major impact could cause serious casualties and damage. In 2013, this was seen throughout the Russian city of Chelyabinsk, as a meteoritic shock wave shattered glass windows across the city and caused more than 1,000 injuries. In that case, the meteorite itself landed in the middle of a frozen lake some 40 miles away, so the incident could have been much worse. Additional vulnerability stems from the increasing importance of electronic communications that can be affected either by a material impact, or by "space weather." (Please refer to the Celestial Impact section for more information.)

Hurricanes

Although hurricanes have little direct impact on Michigan (except for thunderstorm systems and precipitation that may stem from a distant hurricane), it has recently been seen that a sufficiently damaging event (i.e. New Orleans, Florida, New York, or other coastal states) can necessitate large-scale assistance from all states in the union. Hurricanes have the demonstrated ability to cause a catastrophic incident.

Tsunami Events

Whether it originates from a celestial impact, a seismic event, or a volcanic event, a tsunami has the potential to do severe and widespread damage. A tsunami of sufficient size/velocity has the potential to be a catastrophic incident, resulting in the type of damage and displacement seen in the 2005 Katrina/Rita Hurricane Events, the

2004 Indian Ocean tsunami, or the Japanese Fukushima disaster of 2011 (caused by an earthquake, but resulting in a nuclear emergency). These tend to cause public health emergencies, as widespread casualties and devastation can overwhelm hospitals and infrastructure.

Pandemics or other Public Health Emergencies
These types of national emergencies may be purely natural in origin, or they may involve intentionally-caused bio-warfare or terrorist events, or some combination of the two. Naturally occurring pandemic influenza caused widespread precautions around the world during 2009. Although the impact of the novel influenza A (H1N1) virus in that case turned out not to be quite as bad as feared, many were still sickened throughout the country and state, and it was particularly challenging for our schools and health providers.

Some public health emergencies may be the secondary result of a damaging disaster or sabotage incident. In the case of the anthrax cases and scares of late 2001, it made sense to have a state of heightened national alert, despite the fact that most reports of "white powder" eventually turned out to be harmless. Despite the number of false reports and hoaxes, the presence of anthrax in the United States' postal system and key government/media offices was very real, and merited substantial prevention and mitigation efforts nationwide. Coming so soon after the September 11 terrorist attacks, there was initial uncertainty about whether the anthrax incidents were part of ongoing terrorist tactics.

Consequence Analysis

Impact on the Public
These impacts primarily involve the diversion or sharing of Michigan resources to assist other states with major emergency events, such as the devastating impact of hurricanes upon the city of New Orleans. A couple of the most significant possibilities include a New Madrid earthquake (see the Earthquake section), the eruption of a super volcano whose ash may affect weather patterns and cause dusty debris to fall over Michigan, a large scale mass mobilization for purposes of warfare or civil defense (which may cause the dedication of various factories, resources, and infrastructure toward defense and emergency response operations), related mass tragedies involving nuclear attack or terrorism (see those sections), or a large-scale celestial impact (also covered in its own section).

Impact on Public Confidence in State Governance
Those national emergencies that arise from natural hazards, such as flooding, tend to evoke sympathy and generous helping behavior throughout the country. If there is a major shortcoming perceived by the public (usually through the media) in the government's role in such disaster, then significant discontent may arise. Hurricanes Katrina and Rita were a case involving this type of perception and discontent, raising questions about government preparedness and response, on more than one level of authority.

In many emergencies of technological origin, whether a major plane crash or a power failure, there is usually a question of the extent to which government regulation should have been able to prevent or minimize the impacts of the event. Similar issues exist with major human-related hazard events, although it is often recognized that in many such events it was not reasonably possible to anticipate exactly when and how things would go wrong. Matters of national security are often given the benefit of the doubt by citizens, although military operations are routinely treated with skepticism by a significant portion of the population. Prolonged military operations that result in casualties are more likely to raise widespread concern about whether the government is acting correctly and responsibly. However, these same cases also involve a rallying of some patriotic groups who approve of the seemingly direct nature of military action, compared to more abstract policy decisions and approaches. In a diverse democracy, it is normal that the government's authority in a particular area will be lauded by some and criticized (or even feared) by others.

Impact on Responders

National Emergency events would call for the coordination of emergency responders (and associated personnel) between states, and even from across the nation or between nations (e.g. Canada, or its Ontario province). The most direct impact of a national emergency upon responders would be dealing with the logistics of interstate mutual aid (or even its international equivalents). In an event such as the 9-11-2001 terrorist events, or the 2005 Hurricane events, numerous response personnel may have to juggle their time, resources, and efforts involving activities that assist other states or jurisdictions with disaster response and recovery, while simultaneously ensuring that their own state's (or local jurisdictions') preparedness and response needs are also adequately cared for. An additional potential impact may arise from events that occur in one's home jurisdiction after various aid has been granted to some other area—various staff, equipment, expertise, and funds may suddenly be needed "back at home" in the midst of complicated and important response or recovery operations abroad. Extra complexity would also be entailed in the tracking of expenses and the paperwork involved in reimbursement procedures, which might ordinarily be used on activities that are of clearer importance to the home jurisdiction's own emergency needs. One of the effects of national emergencies that does have an impact upon a state's own circumstances, even when not directly impacted by the national emergency event itself, is the potential need to deal with evacuees coming from an affected area, who would need food, shelter, and other types of assistance in living their lives under conditions of displacement and even duress. Such evacuees would tend to have numerous financial and material needs, since the emergency event may have caused severe material hardships for them (or at least temporarily denied them access to their homes and wealth). In addition, various disaster and emergency events tend to cause emotional, social, and psychological hardships as well as material and economic ones, since various trauma may have been experienced during the emergency events (including the loss of family and friends). The uncertainties and stresses of relocations, job loss, etc. would often require social and psychological support structures to be sought (and often provided by the host community) in order to restore a degree of security to the evacuees conditions and lifestyle. As a part of long-term recovery, such evacuees would ideally be able to restore their lifestyles to some sort of normalcy, perhaps even including successful relocation back to their original homes and the resumption of their previous, ordinary life circumstances.

Impact on the Environment

Depending upon the type of event under consideration, environmental impacts upon Michigan may vary widely, or may not directly be felt at all. A super-volcanic eruption, even in the Western United States, could deposit large amounts of volcanic ash across the state. Although superficially similar in appearance to a snowfall event, in some ways, such material would not be collected or dissipated as easily as snow. A major earthquake, tsunami, hurricane, meteorite, nuclear, or terrorist event that causes a wave of immigration into the state (even if only on a temporary basis) may require various forms of development and land use that, under the need to provide emergency services to many people, could be environmentally damaging by the inability to speedily undertake such actions in accordance with long-term comprehensive development plans.

Modern Historical Examples of Major Catastrophic Incidents

Some examples include:

- Major warfare, such as World War II
- Great Blackouts, such as those of 1965 and 2003
- Anticipated or threatened infrastructure breakdowns (such as "Y2K")
- Major terrorist incidents or threats, such as 9/11 and the subsequent anthrax events
- Catastrophic hurricane impacts, as seen in 2005 with hurricanes Katrina and Rita (with many displaced evacuees and a state emergency declaration in Michigan)

Tie-in With Local Planning

Catastrophic incidents (national emergencies) have not yet been identified as one of the most significant hazards in any of Michigan's local hazard mitigation plans, although some hazards (e.g. nuclear attack, q.v.) may be considered to imply that this hazard would have been considered significant, if it had been proposed for consideration during the local planning processes.

CIVIL DISTURBANCES

Collective behavior that results in a significant level of lawbreaking, perceived threat to public order, or disruption of essential functions and quality of life.

Hazard Description

Civil disturbances can be classified within the following four types: (1) acts or demonstrations of protest, (2) hooliganism, (3) riots, or (4) insurrection. Since most of these types of disturbance share similarities with each other, and the classifications presented here are not absolute and mutually exclusive, **it is recommended that this entire section be studied as a whole**. The descriptions that follow, while roughly organized by type of disturbance, provide information of interest in evaluating and understanding all types of civil disturbance, and therefore should not be treated as independent subsections or read in isolation from each other.

The first type, protest, usually contains some level of formal organization or shared discontent that allows goal-oriented activities to be collectively pursued. This first category includes political protests and labor disputes. Many protest actions and demonstrations are orderly, lawful, and peaceful, but some may become threatening, disruptive, and even deliberately malicious (on the part of at least some of those involved either in the protest itself or in reaction to the protest). It is only the latter type of event that should properly be classified as a civil disturbance. The destruction of property, interruption of services, interference with lawful behaviors of ordinary citizens and/or emergency responders, the use of intimidation or civil rights violations, and threats or actual acts of physical violence may all occur during civil disturbance events. Actual Michigan events have included the willful destruction of property and impeded property access during labor strikes, and heated conflicts between opposing participants at political rallies or issue-driven demonstrations. Different risks and forms of disturbance are connected with the nature and perceived importance of the cause, the degree of organization among those who are active in the protest, and the amount of group cohesion among those who are involved.

The second category of civil disturbance, hooliganism, is relatively unorganized and involves individual or collective acts of deviance inspired by the presence of crowds, in which the means (and responsibility) for ordinary levels of social control are perceived to have slackened or broken down. Certain types of events, such as sporting events, "block parties," or concerts, become widely publicized and, in addition to normal citizens who merely seek entertainment, tend to also attract certain types of persons who seek situations in which anonymity, confusion, and a degree of social disorder may allow them to behave in unlawful, victimizing, or unusually expressive ways that would normally be considered unacceptable by most ordinary people. Examples include the disorder that has followed various sporting events and college parties. Although the majority of persons present are ordinary citizens (although many may have some level of intoxication), a minority of persons begins making itself known through unlawful or extreme acts of deviance, and it is from this part of the crowd that the hazard primarily stems. This minority may include persons affected by the use of illegal drugs and alcohol, and may include criminals and persons with mental illnesses (such as antisocial personality disorder) who may either be reacting with extreme hostility to the crowding, noise and disorder, or may have deliberately sought out such crowds and disorder so as to gain opportunities to behave in ways that ordinary circumstances would not allow. Common problems include the widespread destruction of property, numerous types of assault and disorderly conduct, and criminal victimization. It should also be noted that many persons who are normally law-abiding may temporarily behave in unusually aggressive ways during these events, often prompted by an understandably defensive anxiety about the disorder and behavior exhibited by the deviant minority, but also possibly exacerbated by a level of alcoholic intoxication as well as the temptation by some to engage in appealing deviant behaviors that under normal circumstances of social control would not be selected. Many citizens remain law-abiding, but may remain in the area of a civil disturbance either because they live in the area, have activities (including social and recreational ones) that they wish to continue engaging in, have legitimate business to conduct, or because they are curious or concerned and wish to observe or witness the situation as it occurs. The majority of such law-abiding citizens will leave the area in an orderly way when given clear instructions by a legally-recognized

authority to do so. There are cases in which hooliganism may become combined with protest, and thus complicate the situation for law enforcement personnel. In some circumstances, elements of protest are added only by a small minority of participants after the disturbances have already begun, but in other circumstances, protest activity may arise out of concerns regarding the extent and nature of pre-emptive law enforcement activities that were intended to prevent a civil disturbance.

The third type, riots, may stem from motivations of protest, but lacks the organization that formal protests include. Although legitimate and peaceful protests may spontaneously form when people gather publicly with the perception that they already share certain values and beliefs, riots tend to involve violent gatherings of persons whose level of shared values and goals is not sufficiently similar to allow their collective concerns or efforts to coalesce in a relatively organized manner. Instead, there tends to be a diffuse sense of shared discontent, but relatively few norms to shape these strivings into clearly coherent action. For example, widespread discontent within a community that is sufficiently cohesive may quickly take on a set of shared leaders and clear organization, such as a march or chant that is clearly in the form of a protest or demonstration, but in an area that doesn't have the same cohesiveness and shared norms and values, a relatively chaotic form of expression may take place instead, involving assaults, intimidation, and unlawfully destructive expressions of discontent, possibly including the victimization of innocent citizens or businesses who have been selected by part of the crowd to function as scapegoats during their expression of discontent. In addition to the sentiments of discontent that may have sparked the initial activities, however, elements of hooliganism may emerge and even come to predominate, as certain persons may attempt to exploit the social disorder for their own individual ends. In other cases, elements of legitimate protest may also form within this type of civil disturbance, and pockets of organized protest may help to channel and contain the negative elements of hooliganism, looting, etc. that might otherwise threaten all area residents. The complexity of these events for law enforcement can be very great, demanding carefully calculated efforts to analyze the nature of the disturbance, and difficult decisions about how to approach and possibly involve the numerous types of persons, gatherings, groups, and behaviors that may have the potential to either mitigate or exacerbate the situation.

The fourth type of civil disturbance, insurrection, involves a deliberate collective effort to disrupt or replace the established authority of a government or its representatives, by persons within a society or under its authority. Some prison uprisings may fall into this category, although others may more properly be classified as riots or protests, depending upon the presence and extent of specific goals and organization, and the type of action used in achieving such goals. The map at the end of this section shows the locations of major correctional facilities in Michigan. An insurrection has the deliberate goal of either replacing established authorities with a new distribution of power, or with the destruction of established power structures in favor of (usually temporary) anarchy or a smaller-scale set of recognized criminal (gang), ethnic, or other group networks and power-structures. The latter circumstances tend to involve disturbances that exist on a relatively small scale, such as in a single local area or involving a prison network or "cult compound" (or any other similarly self-aware group or subculture with identified collective interests and a network that allows rapid communication and collective action). However, larger-scale insurrections are also possible, involving issues of class conflict or other widespread social inequalities, highly divisive political issues, or other important large-scale events that disrupt the social equilibrium because they illuminate areas in which cultural values are not sufficiently shared throughout the society or region that is experiencing the conflict, disruption, or strain. In many cases, this kind of large-scale social strain has developed gradually over time, and involves an entire series of compromises, concessions, and migrations that may temporarily relieve the disruptive social and value conflicts, only to re-emerge after another period of changes and population growth has caused a breakdown in previous arrangements. This description of the causes of social discontent applies to many protests and riots, as well as insurrection. In cases involving the formation or emergence of significant subcultures or counterculture, such as during the Vietnam era, or when dominant values break down or fail to be established on important key issues or mores, there is the potential for insurrection on a larger scale. The Civil War of 1861-1865 was one such instance, in which the authority of the federal government was either accepted or rejected by various states which then aligned themselves in opposition to each other. Between these two extremes (of a purely localized civil disturbance and a

national civil war) are numerous other possibilities for regional, political, class, or ethnic conflicts that may involve one or more categories of citizen in conflict with others. Examples could include prisoners versus law enforcement personnel, a countercultural group versus the establishment, or a violent political activist group in conflict with selected representatives of a contrary viewpoint. (Some such actions may overlap with those of terrorism, q.v.)

Hazard Analysis

Violent protests, disturbances, and riots have occurred throughout our nation's history. The Stamp Act Riots in the American Colonies in the 1760s, the "Boston Tea Party," and the Revolution itself involved riots and insurrection, as discontent escalated into organized international conflict. Though these events have occurred in the past, they are not considered an acceptable part of ordinary modern life.

Although destructive civil disturbances are rare, the potential is always there for an incident to occur. It is possible that risks for future disturbances may be exacerbated today by the ability of modern mass media (television, radio, the Internet, and various wireless communication devices) to instantly relay information (factual or not), in real time, to large numbers of people. That coverage may help to spread awareness of protests, discontent, riots, disorderly "parties," or other incidents to other areas or interested groups and persons, potentially exacerbating an already difficult situation. For example, media coverage of certain events has, in the past, spurred uprisings inside prisons. Communications technologies were also important in swelling the numbers of "Cedar Fest" revelers in recent East Lansing disturbances. Real-time media coverage of unfolding events is a fact of modern life that is inescapable. As a result, law enforcement officials must be skilled in monitoring all forms of media coverage to anticipate public and perpetrator actions and event progression.

Civil disturbances might be separated into several sub-categories of disturbance that could affect a community.

1. <u>Disturbances that center around a particular facility</u>: the facility could be a prison, a courthouse or other center of government, a stadium or other public meeting place, where large numbers of people may at some point gather in a disruptive fashion that is threatening to the community, its businesses, residents, or quality of life. Typically, a risk assessment would examine the history of the facility, and similar facilities in other communities. Such historical information might identify particular conditions that may cause collective behavior to get out of hand. The degree to which a community contains facilities and conditions that have been associated with civil disturbances will indicate the amount of risk that it faces from civil disturbances. The map at the end of this section shows the locations of major correctional facilities in Michigan.

2. <u>Disturbances that arise in general areas experiencing conflict and hardship</u>: This refers to neighborhoods or regions that have experienced one or more economic, social, or political stresses such as poverty, ethnic intimidation, corruption, and/or the notable presence of illegal activities. These ongoing conflicts and challenges may sometimes flare up into more widespread and blatant conflicts and unrest. The important things to recall about these sorts of civil disturbances is that it is the presence of these conflicts and problems (rather than a particular ethnic or demographic composition) that eventually generates broader disturbances. Care must be taken not to inappropriately "profile" areas based on the characteristics of their residents.

3. <u>Disturbances that interfere with normal business functions</u>: Sometimes, protests are organized in a way that is deliberately designed to disrupt the normal operations of one or more businesses, and may also happen to disrupt surrounding business operations or traffic flows nearby. Many such incidents are political, and eventually addressed through court actions or legislative proceedings. Labor negotiations may have associated employee unrest, including strikes. Protesters may object to the existence of specific facilities or businesses, or their location in a specific area, and while seeking to make such a business or its associated activities illegal, may attempt to take more direct action against its employees or patrons. Typically, the perceived harm from such businesses are either from environmental impacts or injury to persons, or social impacts concerning the image or moral standards associated with an area. In other cases, a political

demonstration may not have anything to do with the sorts of facilities or businesses in an area, but merely seeks the most crowded and inconvenient location so as to maximize the attention that it receives.

There is no specific "formula" recommended here for analyzing civil disturbance hazards, but it is probably helpful to include a historical approach that specifically addresses the social conflicts and political controversies affecting disturbance-prone areas of a community. The various costs of past events (crowd control, vandalism, arson, business disruption and closures, injuries, diverted traffic, negative economic impacts) can be estimated along with their past frequency (e.g. three times in the past hundred years) so as to produce an estimated annual cost. The history of cities with similar conditions can also be analyzed in this way, because the risk of a disturbance may be present even though there have not yet been any historic local events. This is particularly true for communities with newly-developed facilities, in rapidly growing areas, or experiencing significant social and economic changes. Their risk of civil disturbance may be increasing but there is not yet a local history of incidents that can be generalized from.

Impact on the Public

Civil disturbance impacts may include deaths and injuries, disruption of services, and short- and long-term damage to a community's tranquility and reputation (which may also affect its property values). Temporary or permanent business closures may be caused by broken windows, looting, arson, etc. Fear (and its associated security costs) may discourage visitors, shoppers, and tourists, and further cause economic impacts on the area (and associated declines in its property values). Direct property damage can be expected to cause inconvenience, at the very least, to area residents and businesses, and there is a further problem of impeded access to the area's services, and to residents' own personal property.

Impact on Public Confidence in State Government

If discontent underlies a disturbance, some persons may generalize, displace, or attribute the source of their discontent to local or state governments. Some discontent may actually be aimed toward government policies involving the environment, housing, land use, wealth distribution, taxation, military conscription, foreign affairs, labor issues, infrastructure provision, civil rights, or other issues. Although government programs often exist that attempt to address these types of concerns and to ensure that particular values (e.g. civil rights) are respected and supported throughout the jurisdiction, widespread or widely publicized disturbances or demonstrations may undermine the effectiveness of governmental programs and thus weaken public confidence in government. Other types of civil disturbance, such as wild festivities after a sporting event, may undermine public confidence in government if a pattern develops in which illegal behaviors become repetitive and widespread.

Impact on Responders

Frustration and anger may be displaced toward responders, and many citizens may not understand the nature of the motivations, rights, or responsibilities involved in either protest or policing actions. Responders may face unwarranted hostility from citizens, for many reasons, and response activities may be impeded by disruptions taking place. Response, medical facilities, communications, or transport capabilities may be overwhelmed. Psychological impacts on responders may arise from role conflicts and the nature of some of the participants involved in the disturbance (which has some differences when compared with "ordinary crime").

Impact on the Environment

Civil disturbances that stem from labor unrest (or other problems with industrial relations) may involve sabotage that causes the release of harmful substances or otherwise damages the ecosystem in an area. Civil disturbances that involve disruptive forms of collective behavior may include the lighting of fires that release toxins, especially when non-traditional manufactured items are used as fuels. Damage to property may, accidentally or deliberately, include sites that contain hazardous materials. Unruly crowds may disrupt or prevent needed maintenance activities by utility repairmen or industrial workers and thus inadvertently cause environmental problems to occur because of resulting infrastructure failures.

Significant Civil Disturbances in Michigan

As a heavily populated, politically active, well-urbanized and nationally-prominent industrial state with a long history (statehood was achieved in 1837), Michigan has seen many significant civil disturbances, including labor disputes, protests and political demonstrations, social strife, hooliganism and countercultural movements, rioting and prison uprisings. In the case of prison uprisings, the Michigan timeline contains two major points in which uprisings were observed in the modern prison system—the years 1952 and 1981. Event-related hooliganism appears to be a relatively recent historical phenomenon, appearing only after the urbanization of the state's population, the emergence of mass media, and the rise of the modern auto-oriented transportation network throughout the state (the Interstate Highway System started in the late 1950s).

Following are brief synopses of some of Michigan's major civil disturbance events:

Protests

Major labor disputes, in which workers protest and seek changes in their relations with employers, have occurred in virtually every decade in Michigan. However, some have been worse than others in their overall impact on the communities in which they have occurred. Unfortunately, some disputes have turned violent at times, requiring a response by law enforcement agencies to quell the disturbances and maintain order. Numerous political protests have also occurred throughout the state's history. (Please refer also to the subsections on "Riots" for more description of how some of these protests are rooted in social and economic conditions. In cases involving violent protest, the distinction between a protest and a riot primarily involves the level of formal organization and planning behind the activities that occurred.)

Early 1800s Statewide

Native-American resistance to pressures that were compelling land cessions (the first of which took place in 1795), and widespread activity organized by Tecumseh (a Shawnee chief) led to direct military conflict. The famous Battle of Tippecanoe took place in Indiana on the morning of November 7, 1811, killing dozens and wounding several hundred of the forces on both sides. American suspicion that the British may have encouraged various Native American hostilities was one of the major reasons leading to the War of 1812, and during that conflict, certain tribes fought and killed numerous American citizens in Michigan. Overall harm to the Native American tribes was far greater in the long run. Various Native American migrations took place, often compulsory to a greater or lesser extent. A large part of the Potawatomi moved west in the 1830s. The final land cession in Michigan took place in 1842.

1874 to 1879, 1883 to 1885, 1893 to 1897 – Periods of Economic Recession, Depression, and Labor Unrest

One of the patterns evident from even the earliest of modern American industrial recession periods is that the competition for jobs can take on aggressive and illegal forms—especially when there is an over-supply of labor for lesser-skilled or unskilled jobs. Patterns of worker intimidation were reported under these conditions, in many cases organized along ethnic lines, and later leading into larger-scale patterns of violent and destructive means of assertion that came to be associated with some forms of labor organizations (varying with the industry and the time period). To the extent that legal and police powers were used to protect employers when using discriminatory hiring and firing practices, or not providing safe working conditions, or controlling their workers with exploitation and force, such workers might turn to underhanded and illegitimate means to even the odds and assert their rights to safe and reliable working conditions and wages. From these desperate and compelling circumstances of social conflict and inequality, organized crime started to develop and become entangled with legitimate parts of society's social, political, and economic institutions. In other cases, radical and socialist political ideology would eventually connect with violent activism and illegitimate funding mechanisms, some of which were international in scope.

Incidents of workers being intimidated or pressured to give up their jobs (so that their harassers could take them) are documented in Detroit during these time periods, but it is assumed that such activities were more widespread, and were not limited to just the cities. Incidents usually occurred at a small or moderate scale but employed physical violence both for offense and defense, and collectively amounted to large-scale patterns of discrimination and conflict. For example, on August 25, 1893 a group of unemployed men accosted some laborers and teamsters, and fighting led to arrests and injuries. At a meeting of Polish workers the following month, labor advocate Walter Kwiecinski saw five hundred persons and heard claims that public works jobs were primarily being given to Italians and Canadians, while he himself had assembled a list of some 800 unemployed Polish residents seeking such jobs.

April 23, 1891 Detroit

In the midst of a four-day strike, a violent riot erupted in protest against the strikebreaking efforts against the City Railway Company, and a number of streetcars were burned. (It has also been reported that some of the disruption marked a general dissatisfaction with the streetcar services).

April 18, 1894 Detroit "Connor's Creek" labor strike and uprising

During the depression of the 1890s, an excavation project for a water main, just east of the city's boundary at the time, was manned by some 300 workers, who revolted at the conditions for wage reimbursement that the city Water Board had set (estimated at only about one-third of already established wage rates). The workers demanded a higher wage, and stayed on the site throughout that day and the next, to prevent any other workers from being brought in to replace them. On the third day, men arrived from the Wayne County Sheriff's Office, but only succeeded in annoying the workers. A project foreman was attacked by a worker, and the scene quickly exploded into violent chaos when gunshots followed the attack. The mob of workers with picks and shovels surged around the armed lawmen and the project's foremen. Although the violence lasted only a few minutes (resulting in the beating of the foremen and law enforcement officers), there were about 20 serious injuries, and a total of three persons ended up dead from gunshot wounds. By the end of the day, 21 persons had been arrested. Mass meetings took place on April 22, at which many thousands of ethnic workers gathered to press for policy changes.

Spring 1911 Grand Rapids

In a move of historic solidarity, more than 6,000 workers walked out of about 50 furniture factories in Grand Rapids on April 19, 1911, protesting pay and working conditions. Most worked six 10-hour shifts for less than $2 a day. After the walkout, factory owners did their best to maintain production by

bringing in other laborers. Anger built among the striking workers and tensions exploded on May 15, when a company tried to drive strikebreakers in cars to the factory through a crowd of about 1,200 strikers and supporters gathered outside the building. That evening, people poured into the streets from the surrounding neighborhood, where a riot began when the crowd grabbed rocks and pelted the factory company's cars. In the ensuing mayhem, firefighters and police were injured. Police responded by firing their pistols in the air and beating back the rioters with their billy clubs. The fighting drew more people into the streets to help the strikers, swelling the crowd to 2,000. It took firefighters with hoses and a lot more police to rescue the car and the strikebreakers. When it ended at midnight, every window in the factory had been smashed. There were injuries and arrests but no deaths. The riot was one of the few violent confrontations in what was one of the largest strikes by a non-unionized workforce.

July 1913 to 1914 Upper Peninsula

A copper miners strike in the Upper Peninsula resulted in months of vandalism, murders, threats and intimidation, harassment, and violence, as strikers and unionists clashed with strikebreakers and law enforcement personnel. This conflict pervaded the entire copper mining region, and did not merely occur at the work site locations themselves. Nearly all mines were closed down in the area, and nearly 15,000 miners stopped work. Rioting and violence was involved in the initial July clashes that prevented non-striking miners from going to work. Things calmed for a while, until some mines attempted to re-open in August. Strikebreakers (often new immigrants to the country) were terrorized away from the mines, and gun battles also took place which resulted in deaths. Court cases started, to try to reverse laws that had developed in opposition to the strike. By October, several larger mines had opened, and many former workers moved out of the area. A union-organized Christmas party in Calumet turned disastrous when someone yelled "Fire!" A long stairway led to inward-opening exit doors and in the stampede of persons leaving the building, people were pushed by the crowd and started falling down the stairs and being crushed in the crowding at the exit doors. In the end, more than 70 persons were killed, most of whom were young children. Following a disagreement about whether the victims families should accept gifts, a local union headquarters was stormed and its leaders threatened with lynching. By early 1914, the union announced that it was giving up the strike.

August 5, 1919 Muskegon

Muskegon residents protested when the Muskegon Traction & Lighting Company attempted to raise street car fares by 1 cent (from 6 cents to 7 cents) on the evening of August 5, 1919. Over 30 people, unarmed, tumultuously assembled in the streets near city hall. An argument between a few factory workers and a street car conductor escalated into a citywide rampage by a mob of nearly a thousand. They obstructed the passage of street cars, took street cars off their tracks, overturned them, and destroyed the windows and the fixtures of the cars. By dawn on August 6, the Michigan Traction & Lighting Company's car barns were destroyed and 13 street cars were also destroyed. Warning shots fired by the police only further enraged the rioters, forcing the officers to flee for their lives. No determined or organized effort was made by the police force of the city to suppress the tumult or to arrest those engaged in the incident that lasted from about 6pm until 4am. Citizens called upon the fire department to assist in suppressing the riot, but the organization refused to respond. Therefore, no arrests were made of any person engaged in the disturbance. The incident destroyed a sizable portion of the fleet, with property destruction estimated at $100,000 to $125,000, (about $1.3 to $1.5 million in 2011 dollars.) The street car service of the city was interrupted and suspended for a period of two weeks. The mayor and the common council took few steps to investigate or discipline the fire or police departments for failing to for suppress the riot and disperse the crowd. Therefore, the mayor and eight aldermen of Muskegon were found guilty of official misconduct and willful neglect of duty in connection with the street car riots.

March 6, 1930 National Protests

As the full effects of the Great Depression were being felt, discontent became organized into a nationwide series of gatherings, which included the involvement of communist groups. In Detroit, many tens of thousands participated, and violence resulted when protesters resisted police efforts to disperse them.

March 1932 Dearborn

A "Hunger March" led by 10,000 demonstrators (most of whom were laid-off autoworkers), included a battle with police that left four marchers dead and dozens injured. The Detroit portion of the march was peaceful, but as Dearborn was reached, police tear gas was reacted to with the throwing of stones and mud clumps. Dozens of persons were arrested.

1936 to 1937 Flint, Detroit, Dearborn, and other cities

A series of labor conflicts wracked the auto industry during these years. In a series of "sit down strikes" that started in Flint on December 30, 1936, industrial sites were occupied by workers who sought improvements in their wages and working conditions. Many picketers wielded sticks and other potential weapons, and many industries had their own teams of "muscle" and security men, as well as the general support of law enforcement personnel. At the time, the law gave more recognition to the right of factories to use force to protect their property than it did to unions and workers to organize and protest working conditions. On January 11, 1937, tear gas and fire hoses were used against picketers in Flint, who employed various makeshift weapons, and the conflict then escalated to the use of firearms by police. Several dozen persons were injured on both sides of the issue. In Dearborn, on May 26, 1937, union representatives were viciously attacked by company security men, while meeting with news reporters in a widely publicized event known as the "Battle of the Overpass." Many nearby persons were also attacked, beaten, and driven away, including women who wanted to hand out leaflets. Various persons suffered severe injuries and were hospitalized. The reporters themselves were harassed, and photographs of the event that soon became world-famous had almost been confiscated by company strongmen.

NOTE: Various issues involving union organization took decades of discontent, conflict, and legal and political action to be ironed out into the modern forms in which labor-industrial relations exist today. Although these issues became more stable by the second half of the 20th Century, some of their aspects are still evolving even today.

1948 Detroit

Protests by white residents of the Fenkell-Linwood area (Quincy and Baylis Streets) took place in an effort to discourage African-American residents from living in the area. Although this incident was not itself considered to be a riot (see the subsection that follows), it was indicative of the potential for such disturbances to occur in the area. Among other problems in the area, at least one other serious disturbance occurred two years later (see the February 1950 entry in the Riots subsection that follows).

1964 to 1972 Numerous Anti-War Demonstrations at multiple locations

Student-led anti-war protest demonstrations across the country, beginning with a major uprising in Berkeley, California in 1964, spread to virtually every major university campus (including several in Michigan) by the late 1960s and early 1970s. Some protest demonstrations were very large and involved violence and rioting, sometimes increasing in response to the arrival of police. In Michigan, major demonstrations occurred in East Lansing, Ann Arbor, and other university communities. In East Lansing in May of 1972, thousands of student protesters blocked Grand River Avenue for several days, in anger over escalating U.S. activities in the Vietnam War. Eventually, Michigan State Police and local law enforcement authorities ended the blockade.

1960s and 1970s Detroit, Flint, Lansing

In the 1960s and early 1970s, strikes between the United Auto Workers Union and the major automobile manufacturing companies headquartered in the state (General Motors, Ford, Chrysler and American Motors) occasionally led to clashes with police. These strikes primarily affected Metro-Detroit, Flint and Lansing.

July 1995 to 1997 Metro Detroit

The most recent period of serious labor unrest has been the Detroit Newspaper Strike, which started in July 1995 and continued on through 1997. (The labor dispute officially ended in December 2000 when the involved unions ratified new contracts, 5 ½ years after the strike began.) The strike was marked by periods of sporadic violence and involved approximately 2,500 workers from Detroit's two daily newspapers. The strike negatively impacted many facets of the community, and at times required extensive use of law enforcement resources to supervise strike-related activities and maintain order. The most significant strike-related activity occurred on June 20-21, 1997, when a national union mass demonstration was held in support of the strikers, drawing over 100,000 people to Detroit.

Hooliganism

1970s-1990s Detroit Arson and "Devil's Night" Disturbances

On the night before Halloween during these decades, the expected number of fire calls was seen to grow to well beyond the norms for the rest of the year, and seriously challenged the ability of fire workers to respond to. Although not solely an occurrence of hooliganism, as a reputation became established for the ongoing pattern of "Devil's Night" fires and disturbances, it certainly attracted hooligans that compounded the problem, and the difficulties of dealing with it. Although Devil's Night had traditionally been associated with youthful pranks (which also prompted more serious instances of vandalism and delinquency), only a portion of the arson events can be attributed to mere hooliganism. Rather, the loss of structures were in many cases caused by deliberate criminal acts, sometimes with the intention of removing vacant properties that in their cumulative disrepair had become dangerous to enter or be around, and that in other cases were perceived as attractive locations for illegal criminal enterprises. The problems were mitigated through a combination of community partnerships, volunteer activism ("Angel's Night"), more concentrated preparation and law enforcement, and expanded demolition and clearance activities on the part of the city, as well as the gradual disappearance of the most readily targeted structures and an overall decline in city population over those decades.

October, 1984 Detroit Sports Championship Melees

The success of Detroit's professional sports teams is sometimes unfortunately marred by violence and rioting that can gain significant national attention. After the Detroit Tigers won the 1984 World Series, the ensuing celebration turned ugly when cars were overturned and burned and nearby homes and businesses damaged. This was widely covered by the national media.

June, 1990 Detroit Sports Championship Melees

After the Detroit Pistons won their second NBA Championship, the "celebration" following the victory resulted in eight deaths and numerous injuries. This was widely covered by the national media and tarnished Detroit's image at a time when it should have been able to peacefully revel in its sports success. Unfortunately, similar scenarios have played out in other major cities in recent years after professional sports teams have won a championship.

1980s-early 1990s East Lansing and Mt. Pleasant Civil Disturbances

Several clashes between large groups of students and police occurred in East Lansing in the late 1980s over an annual street party known as "Cedarfest." Injuries and property damage resulted from these disturbances, which also involved the use of tear gas to try to disperse rowdy and hostile crowds. Central Michigan University in Mt. Pleasant was also witness to a series of similar parties turned into riots in the 1980s and early 1990s, with the resulting clashes often involving hundreds of students and police.

September, 1997 East Lansing Civil Disturbances

On September 6, 1997, over 500 revelers celebrating a Michigan State University football victory gathered on Gunson Street in East Lansing and set bonfires, destroyed trees and street lamps, shattered glass, and hurled bottles at police.

May, 1998 East Lansing Civil Disturbances

On May 1, 1998, a student protest against Michigan State's decision to ban alcohol at a popular on-campus partying place for football games erupted into a riot that spilled onto the streets of East Lansing, ultimately involving over 3,000 people. The riot forced East Lansing police to use tear gas to disburse the crowd, but not before several large fires were set, traffic was blocked on Grand River Avenue, and rocks and bottles were hurled at police.

March, 1999 East Lansing Civil Disturbances

On March 27, 1999, the largest and most serious disturbance occurred after Michigan State's loss in the NCAA Final Four basketball tournament. The melee lasted for several hours before police were able to quell it with tear gas. Total property damage exceeded $250,000. Over 130 people were arrested and charged with various crimes stemming from their participation in the riot. Nearly 120 were convicted and ordered to serve jail time, pay fines, or both. Several students were also expelled from the university. Follow up investigations by police revealed that some of these incidents were spontaneous events, while others were pre-meditated riots with the sole purpose of wanton destruction of public and private property. These types of riots continued to occur the for the following few years during the basketball tournament season, resulting in thousands of more dollars in damages and leading to several more arrests.

September 9, 2001 Kalamazoo Civil Disturbances

In the early morning hours of September 9, 2001, a riot broke out at a block party near the Western Michigan University and Kalamazoo College campuses in Kalamazoo. The crowd, which police estimated at 2,500, pelted officers with bottles and rocks, tore down street signs, broke windows, and set fires. Three police cars were heavily damaged and two police officers were injured in the melee. Twenty-one people were arrested—many charged with felonies—and nearly 50 were ticketed for underage drinking and other misdemeanors.

March 17, 2002 Kalamazoo Civil Disturbances

On the night of March 17, 2002, a spring break party around a bonfire near Western Michigan University got out of hand as people clashed with police in riot gear trying to disperse them. A car was set on fire and several other parked cars were damaged. Rioters climbed telephone poles, pulled down traffic signs and set several dumpsters on fire. About 30 officers moved in when someone threw a bottle through the windshield of a passing car. Three people were charged with unlawful assembly and a fourth was accused of assault.

October, 2006 Saginaw Arson and "Devil's Night" Disturbances

The 42 fires reported in Saginaw's two-day period before and during Halloween were well above what would normally be expected during an ordinary two-day period. The community responded seriously and quickly to mitigate this hazard, and subsequent years had only about a quarter (or less) of this number of fires on those two days.

December 8, 2013 East Lansing Civil Disturbances

On the night of December 8, 2013, following a Michigan State University football victory. a crowd estimated between 2,000 and 3,000 people at its peak assembled on the streets of the Cedar Village Apartment complex, where numerous similar gatherings had occurred in the past. At least 57 fires were set and used to burn couches, lawn furniture, trees, shrubs, mattresses, bikes, and other available items. There was no tear gas used to disperse the crowd, but 15 persons were arrested. While the crowds at Cedar Village mostly dispersed peacefully, there were in other areas of the city in which officers had rocks, beer cans, glass bottles, horseshoes, and numerous other items thrown at them.

Riots

March 6, 1863 Detroit Faulkner Riot

False reports of the victimization of two girls led to the storming of black neighborhoods in Detroit by white mobs. Dubbed the "Faulkner Riot," extensive property damage took place, about 200 were left homeless, 2 persons were killed, and at least 20 were injured.

1885 to 1887 Detroit Parish-related Disturbances

Ethnically distinctive areas of major cities may involve issues that those from other ethnic groups may find unfamiliar or even mysterious. Such was the case in expanding Detroit, as a large number of Polish immigrants began to make a place for themselves, after their homeland had been "partitioned" among German, Russian, and Austrian conquerors. The foreign-born population of Detroit was about 40% in 1880 and 1890, and about three-quarters of city residents reported having either fully foreign or "mixed" foreign parentage in 1890. Thousands of those with Polish identities habitually stayed mainly within their own ethnic neighborhoods and parishes, since they hoped to be able to return to their homeland in the future (a Polish state was indeed re-established in 1918, at the end of World War I).

Riots and disturbances surrounded the suspension of Father Dominic Kolasinski from his parish, St. Albertus (at St. Aubin and Canfield Streets). The Polish area of the city's near east side was affected by antagonisms and rivalries that led to numerous gatherings, protests, disorder, and even outright violence. His loyal followers tended to share a common language and area of origin in their native Poland, and they mistrusted and defied the decrees of the area's German Bishop in his suspension of Father Kolasinski. Antagonisms toward Father Kolasinski's accusers, and toward the Parish's replacement clergy and the Bishop himself, caused numerous gatherings and protests over the course of many months.

On December 1, 1885, a crowd swarmed around the church after ejecting a replacement priest, followed by a 20 minute melee with police. A crowd protested around the home and business of one of Father Kolasinski's accusers. On the next day, an even larger crowd pelted police-accompanied replacement priests, and about a thousand persons surrounded an accuser's home and store on Hastings Street. During the following weeks, various crowds assembled to block the replacement priest from taking up duties at the parish, and threats of violence toward Kolasinski's accusers increased. On December 22, 1885, about 50 "roughs" engaged in demonstrations and threats against the new priest. Finally, on December 24-25, there was a standoff between different factions (of about 50 persons each) gathered to support or protest the reinstatement of Father Kolasinski, and although this confrontation was quieted by police, gatherings recurred in the early morning hours, with hundreds of additional persons arriving per hour around the church, hoping for an early Christmas Mass. By the dawn hours, a crowd of several thousand had assembled, and then marched to confront the Bishop at his downtown residence on Washington Street. The Bishop left discreetly to celebrate Mass at a different church, causing crowds to find him and then be turned away. The crowds dispersed by midday but about 400 recongregated at St. Aubin and Willis, surrounding the store and residence of one of Kolasinski's accusers. After several hours of shouting and threats, a resident emerged with a handgun, killing one person and wounding another, before police stormed the house and arrested all three men inside. The next day, about 2000 Polish residents gathered at St. Albertus and then surrounded the store and home where they smashed all windows until its owner fired shots in the air and more than 100 police were able to divert and control the crowd. Subsequent months throughout 1886 saw occasional disturbances of smaller magnitude: a March 5 gathering of up to 500 shouting persons at Fredro Hall (at Russell and Leland Streets), an April 9 clash between Polish factions at Fredro Hall, and an August 16 anti-Bishop demonstration in which a crowd near the church broke windows on a nearby convent and orphanage. On March 20, 1887, more than 3000 persons gathered for an anticipated re-opening of St. Albertus, which resulted not only in disappointment but to continued clashes between Kolasinski's defenders and opponents, in which several serious injuries of policemen and activists resulted. A girl was wounded by a police gunshot, and 50 officers eventually managed to clear the streets. Numerous arrests followed over subsequent days. On May 19, 1887, more than a thousand persons gathered to expel a new priest, but were themselves dispelled by about 100 organized men. By 1889, following the resignation of the German Bishop, his replacement by a new Irish one, and the departure of one of Kolasinski's accusers, these sorts of disturbances had calmed quite a bit, although a great deal of alarm and misunderstanding had spread throughout the city and led to a cycle of stereotyping and segregation of "the Polish quarter" and its residents. A supporter of Kolasinski claimed that there were at least "5,000 of us, besides women and children," who would go without a church while waiting determinedly for the priest to be allowed to return. By 1889, Kolasinski had returned and started to lead new services for his supporters (estimated as numbering ten thousand or more), also starting the construction of an alternate parish three blocks to the west of St. Albertus.

1914-1918 World War I Ethnic Hostilities

Ethnic hostilities increased as World War I started and progressed (American involvement in the war began in 1917). The loyalty of various Germans was questioned, as well as persons of other ethnicities corresponding to the hostile Axis powers in Europe, and various pressures and hostilities resulted in the vandalism of homes and businesses.

February 28, 1942 Detroit "Sojourner Truth" Housing Clashes

A riot took place when white residents protested the right of 200 African-American defense workers to move into a new housing project (named after Sojourner Truth) in the northeast part of the city. An angry picket line was formed, and conflicts escalated when one of the new residents tried to cross the line in a car. More than a thousand persons were in the area, participating in the conflict in some manner. More than 40 persons were injured and 220 were arrested.

June 20-21, 1943 Detroit Major Riot

A series of small racially-oriented skirmishes in Detroit escalated into a major riot, as about 100,000 persons massed near downtown Detroit (not all of whom were actively involved in violence, however). The riot quickly overwhelmed city and state police, so Federal troops in armored cars were brought in at Governor Harry Kelly's request to help restore order. The riot was quelled after more than 36 hours, but not before it claimed 34 lives and caused over 700 injuries. More than 1,800 arrests were made.

February, 1950 Detroit Ethnic Hostilities

Disturbances in the Fenkell-Linwood area (Princeton Street) involved white protesters stoning a house and vandalizing a car belonging to a new African-American resident, followed by at least one antagonistic meeting (150 residents at a neighborhood association) that expressed a mixture of fears, bigotry, and protests at changing residential patterns and policies in the city. (Please refer to the General Comments about Urban Civil Disturbances subsection that follows in this document.)

Aug. 30 - Sept. 5, 1966 Benton Harbor Riot

After a fatal shooting that had racial significance, street violence erupted in the city. The rioting included stones being thrown at cars. A man was arrested for the shooting, and things eventually quieted after the National Guard was called in, on the order of Governor George Romney.

July 23 to 29, 1967 Detroit Riots

One of the most infamous riots in the United States occurred in Detroit from July 23-29, 1967. This uprising resulted in the greatest loss of life and the largest destruction of property of any of the national riots of the 1960s. Looting, burning, and sniping reached a scale unknown to in a U.S. city in the twentieth century, exceeded only by the 1863 New York City Draft Riot. The violence erupted when police raided an illegal after-hours drinking club (a "blind pig"), arresting numerous patrons and the bartender. Shortly thereafter, a crowd that had gathered began to loot nearby stores. Within an hour, the looting had spread to a 16 block area, with many stores having been plundered and set afire. Police estimate that over 5,000 persons were actively involved in the rioting, which quickly engulfed large sections of the city - as much as six to seven miles out from the initial flash point. Over 150 fires consumed a 15 block area and burned uncontrolled when firefighters were forced to withdraw after being pelted by objects.

In response to the rioting, then-Governor Romney declared a state of public emergency, mobilized nearly 8,000 National Guardsmen and several hundred Michigan State Police troopers to assist in restoring order, and requested supplemental Federal military assistance. Nearly 5,000 Army paratroopers were dispatched to Detroit to assist the National Guard and state and local police units. Over 13,000 military troops, guardsmen, and police worked to quell the disturbance. Over 7,000 people had been arrested for their participation in the incident, 43 people had been killed, and over 1,000 had been injured. Five thousand had been left homeless. Over $50 million in damage had been incurred, due to the fires and looting.

The 1967 Detroit riot was part of a series of riots that occurred in cities across the country in the mid-1960s. In 1967 alone, over 160 riots occurred in U.S. cities and towns, many in communities with less than 25,000 in population. Outside of the Detroit riot, the other mid-60s riots that gained most of the national attention were the August, 1965 riot that occurred in the Watts section of Los Angeles (which resulted in 34 deaths, 1,000 injuries, 600 damaged buildings, 4,000 arrests, and $35 million in losses) and the July, 1967 Newark, New Jersey, riot, which caused 26 deaths, 1,500 injuries, and 1,400 arrests. More than 300 fires were reported in the latter disorder, and property damage was estimated at more than $15 million. Rioting continued in 1968, following the assassination of Martin Luther King, Jr. Disturbances occurred in over 130 cities, with the final tolls standing at 46 deaths, 7,000 injuries, more than 20,000 arrests, and nearly $100 million in damage (mostly from the more than 2,600 fires set). Over 80,000 military troops were used to quell those incidents.

July, 1975 Detroit Riot

Disorder followed the shooting of a black youth (who died the next day) by the white owner of a bar near Livernois and Fenkell. Crowds numbering several hundred gathered and began to damage area businesses, causing tens of thousands of dollars worth of property damage. Fighting broke out, focused on racial antagonisms. An uninvolved motorist trying to drive through the area ended up being pulled from his car and died three days later from the injuries he sustained. Mayor Coleman Young, who at the time had only been recently elected, helped to calm the disturbance by bringing in hundreds of law enforcement personnel and also personally walking the area for the following two nights. The bar owner was charged with second-degree murder, and the bar itself had been trashed by the crowds. About 100 persons were arrested.

June 16-17, 2003 Benton Harbor Riot

The city of Benton Harbor erupted into riots on June 16-17, 2003, after a motorcyclist being chased by police crashed into an abandoned house and died. Two nights of violence brought hundreds of police to the area to calm the citizens who felt exasperated with community conditions and circumstances. Rioters roamed a six to eight block area, setting fires and attacking passers-by, police officers, and firefighters. One person was shot in the shoulder and others were beaten and stabbed. In all, about 15 people were injured. It was estimated that about 23 homes were damaged or destroyed by fire. A total of about 10 people were arrested.

Insurrection

Early 1800s Statewide Native American Struggles

Native-American resistance to pressures that were compelling land cessions (the first of which took place in 1795), and widespread activity organized by Tecumseh (a Shawnee chief), led to direct military conflict. The famous Battle of Tippecanoe took place in Indiana on the morning of November 7, 1811, killing dozens and wounding several hundred of the forces on both sides. American suspicion that the British may have encouraged various Native American hostilities was one of the major reasons leading to the War of 1812, and during that conflict, certain tribes fought and killed numerous American citizens in Michigan. Overall harm to the Native American tribes was far greater in the long run. Various Native American migrations took place, often compulsory to a greater or lesser extent. A large part of the Potawatomi moved west in the 1830s. The final land cession in Michigan took place in 1842.

1952 Jackson County Prison Uprising

Although violence is a fact of life in Michigan's prisons, large-scale, deadly prison uprisings are relatively rare. However, there have been two such incidents in the Michigan prison system over the past 50 years that have caused significant injury, loss of life, property destruction, and response support from other state agencies and the involved local government. The first of those incidents occurred from April 20-24, 1952, at the Southern Michigan Prison in Jackson. That five-day siege resulted in the death of one inmate and serious injury to nine others. More than a dozen guards were held hostage throughout the uprising. Eventually, all were released, though several had been beaten or were otherwise wounded. Officials estimated that approximately one-half of the prison's 6,500 inmates had participated in some way in the rioting. Numerous prison buildings had been severely damaged or burned to the ground. When the dust settled, the official damage estimate was put at $2.5 million. The damage was not fully repaired for several months. Throughout the uprising, the Michigan State Police had provided critical assistance in containing and eventually controlling the riot. The last Michigan State Police trooper left the prison on Labor Day, over four months after the uprising began. Sometime after that, a new Department of Corrections riot squad was formed to handle any such incidents in the future. It is interesting to note that this incident at Southern Michigan Prison was the worst in a string of 30 major prison riots that occurred across the country in 1952 and 1953.

1981 Jackson, Marquette, and Ionia Counties Prison Uprising

The second major prison uprising in Michigan occurred over the Memorial Day weekend in 1981 at the State Prison of Southern Michigan in Jackson, Marquette Branch Prison in Marquette, and the Michigan Reformatory in Ionia. The uprisings, which occurred on May 22 at Jackson and Ionia, and again on May 26 at Jackson and Marquette, were thought to be related. Although all three facilities were damaged, the State Prison of Southern Michigan incurred the worst damage. The disturbances began when officials from the Michigan Corrections Organization at the State Prison of Southern Michigan attempted to take administrative control of the prison and lock down prisoners over the Memorial Day weekend. Rioting broke out at the facility, which then spread to the Michigan Reformatory in Ionia later in the day. The situation temporarily settled over the weekend, but rioting began again on May 26 at the State Prison of Southern Michigan, which then spread to Marquette Branch Prison. Both disturbances were quelled later in the evening, but only after major physical damage had been inflicted on the facilities.

The final damage figures for the two days of rioting were significant. The May 22 disturbances at the State Prison of Southern Michigan and the Michigan Reformatory resulted in 67 inmates and 27 staff members being injured, many requiring hospitalization. The May 26 disturbances saw an additional 44 staff members injured, along with 42 inmates. Fortunately, no lives were lost in either disturbance. The physical damage to the three facilities totaled $5 million, with another $4.1 million in riot-related costs incurred. Damages at the State Prison of Southern Michigan included fire and smoke damage to eight cell blocks, destruction of eight modular units, and damage to the academic vocational building, the inmate store, and the food service facility. The master key system also had to be replaced. At the Michigan Reformatory, two cell blocks were damaged, in addition to the prison chapel, the food service building, and the school. The master key system also had to be replaced at this facility as well. At the Marquette Branch Prison, two vocational education buildings were destroyed, and the industries building, service building, and six cell blocks were damaged.

It took many months for the damage at the three facilities to be totally repaired and services brought back to normal. In the end, legal and disciplinary actions were taken against 19 corrections personnel and numerous inmates for their roles in the two disturbances.

August 13, 1995 Lenawee County Prison Uprising

At the Gus Harrison Correctional Facility, three housing units were taken over by prisoners. Several correctional staff were assaulted as they attempted to secure prisoners during a power outage. Several prisoners were also assaulted by the rioters, as well. Fortunately, no lives were lost as the housing units were eventually retaken by correctional gun squads. During the incident, the facility was assisted by the Michigan State Police, Lenawee County Sheriff's Department, and the City of Adrian Police Department. A great portion of the housing units sustained heavy damage during the disturbance.

General Comments about Urban Civil Disturbances

Various racial and ethnic bigotries have been expressed at numerous times and locations throughout Michigan, sometimes exacerbated by major news events (which can be local, state, or national). For example, anti-German sentiments were frequently expressed during World War I. Some of these ethnic and racial antagonisms were institutionalized and enforceable by laws, contracts, or other arrangements. One example of this would be the "restrictive covenants" that prevented the sale of designated properties to those in specified minority groups. The use of restrictive covenants became unconstitutional as a result of a court decision (Shelley vs. Kramer) in 1948, but similar de facto patterns of residential pressures and segregation would still be evident for many decades afterward.

During periods of turmoil, social change, and immigration, the challenges of these large-scale social patterns often correspond with the symptoms of social conflict—in the attitudes, behavior, and policies of individuals, groups, organizations, and institutions. The number of civil rights protection programs and options has increased over time, and the Michigan Department of Civil Rights was formed in 1965, but it is useful to be aware of the possibility that widely publicized (and sometimes poorly understood or misrepresented) events may cause surges in conflicts and problems. Stereotyping, scapegoating, and discrimination can lead not only to individual crimes, but also to the disruption of neighborhood residents and the escalation of mistrust, fears, and protests into riotous incidents. It is also possible for these tensions and incidents to endure and to form an ongoing pattern of social conflict (see the section on Terrorism and Major Criminal Incidents).

Further complicating the situation, particularly in urban areas, is that certain types of "illegitimate opportunity structures" (criminal organizations) have been known to give preferential treatment to those from particular family or ethnic backgrounds. Within the complexity and dynamics that are present in modern large cities, it has been very common for individuals to mistake or confuse their individual experiences of crime, poverty, etc. with larger-scale patterns of ethnicity, race, and social class, and to draw unwarranted conclusions about "all" persons who are perceived to be members of a particular class or group.

In actuality, social science has shown that within every large descriptive category of persons (age, race, gender, nationality, social class, etc.) there is a great deal of diversity. This diversity becomes apparent as an individual has more experience and interaction with a wide array of persons from a given background (e.g. ancestry or national origin), social situation (e.g. poverty), or socially defined category (e.g. ethnic identity), or with particular physical characteristics (e.g. sex). There usually turns out to be just as much diversity within any such large categories of persons as there is between them (to the extent that it is even valid to try to describe or define "them" collectively as a group). There is no quick shortcut to fairly and validly judge a person's character or motivations, based upon such large-scale classifications as gender, race, or social class—one must instead actually observe and get to know each person as an individual in order to start to make such assessments. (Gang-related clothing or the exhibition of countercultural symbols may be perceived as individual choices, rather than confused with a broader ethnic or other category, but even in such cases, it is often very difficult for a stranger to be able to judge the degree of authenticity and the actual meaning of such symbols for the persons who use them. On the

other hand, an individual's decision to adopt a cautious or wary attitude in an unfamiliar setting or when meeting new persons is not quite the same as exhibiting deliberate prejudice, bigotry, or discrimination.)

National Situation

Nationally, over the past 50 years, a significant civil disturbance has occurred somewhere in the country in virtually every decade. Violent rioting has been particularly troublesome, with major events having occurred in Los Angeles, Newark, and Detroit in the summers of 1967-68, in Miami's Overtown and Liberty City areas in 1980 and 1989, in Los Angeles in 1992, in St. Petersburg, Florida in 1996, in Seattle in 1999, in Cincinnati in 2001, and in Benton Harbor in 1966 and 2003. The toll in terms of injury, loss of life, and property damage from these events has been staggering. Damage from the 1992 Los Angeles riot alone was in excess of $1 billion. Perhaps even more tragic has been the lingering, negative impact and loss of investment in these ravaged communities. Many of the riot areas still have not fully recovered from the damage, destruction, and negative image brought on by these events.

Programs and Initiatives

Civil disturbances are often difficult for local communities to handle. Officials must walk a fine line between the constitutional right of individuals and groups to assemble and air grievances, and the overall needs of the community to provide essential services, ensure the personal safety of citizens, prevent property damage, and facilitate normal commerce. Fortunately, most demonstrations and large public gatherings are held in a peaceful, responsible manner. However, there never seems to be a shortage of groups whose primary objective is to disrupt normal activities and even cause injury and property damage.

Handling events that could result in civil disturbance is a difficult operation, at best. Normally, law enforcement personnel are outnumbered several times over, and they are often ill equipped and under-trained to handle a large, unruly crowd. Many police departments offer some type of disturbance training, but because the events happen so infrequently, and turnover is relatively high in law enforcement positions, constant re-training is necessary. Unfortunately, that training costs money, and many departments are already hard-pressed to meet basic training needs. Nevertheless, proper training of law enforcement personnel, adequate resources, and incident anticipation and planning are the keys to successful incident management. Mutual aid agreements tend to be vital to the timely handling of civil disturbance events.

Another important element in response to civil disturbances is the proper visual documentation of the incident from start to finish. To that end, many police departments have begun to videotape incidents that could result in a civil disturbance. Such documentation can be used at a later time to identify criminal acts and perpetrators, review actions, and make determinations as to an incident's cause.

In most civil disturbances, local law enforcement resources, augmented where necessary by the Michigan State Police, are sufficient to manage and end the incident. If, however, local resources are not adequate, the Michigan National Guard can be activated to provide for the immediate preservation of public peace and safety. A Governor's declaration of emergency is necessary to activate the Michigan National Guard.

College Campus Anti-Rioting Law

In the wake of the riot that occurred at Michigan State University in 1999, a new state law (2000 PA 51) aimed at curbing rioting on or near (within 2,500 feet of) Michigan's public colleges and universities took effect on June 1, 2000. This Act, which amended the State Code of Criminal Procedure, allows judges to ban campus rioters and others convicted of riot-related offenses, unlawful assembly, and civil disorder from all public college and university campuses in Michigan for up to two years for a felony conviction, or one year for a misdemeanor. (Note: Although the Act is intended to serve as a deterrent to the type of unlawful behavior exhibited at Michigan State University and other college campuses in recent years, civil libertarians have expressed concern that the law, as written, could potentially be interpreted in such a manner as to punish persons for simple, non-violent acts of civil disobedience.)

Crowd Control

In some cases, crowd control techniques are critical to the avoidance of injuries and death. For example, on December 3, 1979, in Cincinnati, Ohio, inadequacies of event planning and crowd control led to the trampling deaths of 11 attendees at a rock concert. About 10 others were injured at this event, even though the crowd itself was not riotous or violent. Much was learned from this incident, however, and a useful and insightful analysis of this event was made available at http:www.crowdsafe.com/taskrpt/toc1.html for general study.

Prisons

Prison uprisings are first contained by Michigan Department of Corrections facility squads, composed of trained Correctional Custody personnel. Department Emergency Response Teams (ERT) then assign their members to resolve the situation. ERT members are specially trained personnel who respond to security needs or emergency situations which arise during daily institutional operations. ERT also responds to situations which threaten the safety or security of any correctional institution, or which pose a threat to the community. Additional units may be brought in from other nearby facilities, if necessary, to quell the disturbance. If those resources are not sufficient to manage and end the uprising, specially trained officers from the Michigan State Police can be activated to assist Department of Corrections personnel. The Michigan State Police may also be mobilized to provide perimeter security around the facility, and to augment resource needs. In extreme cases, Michigan National Guard military personnel can be activated to assist with the restoration of order within the facility.

Hazard Mitigation Alternatives for Civil Disturbances

- Some suggest that design, management, integration, and lowered density of poor or blighted areas will reduce vandalism, crime, and some types of riot events. Crime Prevention Through Environmental Design (CPTED) is a field of planning that deals with this.
- Structure and property insurance in risky areas, combined with anti-arson practices.
- Design requirements for schools, factories, office buildings, shopping malls, hospitals, correctional facilities, stadiums, recreation areas, etc. that take into consideration emergency and security needs.

Tie-in with Local Hazard Mitigation Planning

Because many means of implementing mitigation actions occur through local activities, this updated MHMP places additional emphasis on the coordination of State-level planning and initiatives with those taking place at the local level. This takes two forms:

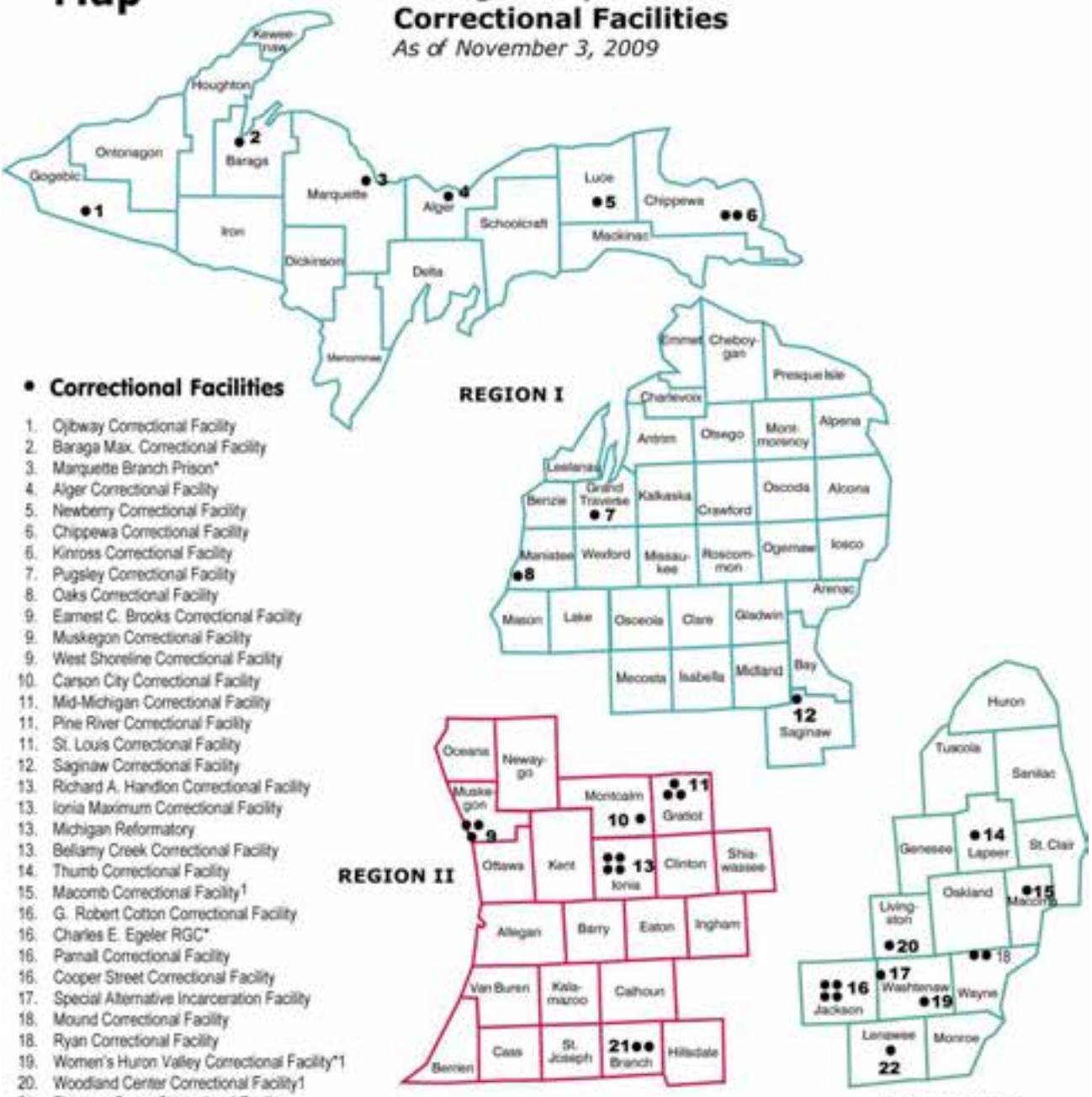
1. The provision of guidance, encouragement, and incentives to local governments by the State, to promote local plan development (including a consideration of drought conditions), and
2. The consideration of information contained in local hazard mitigation plans when developing State plans and mitigation priorities.

Regarding the first type of State-local planning coordination, MSP guidance has included the “Local Hazard Mitigation Planning Workbook” (EMD-PUB 207), which is currently being updated for release by 2015. For the second type of State-local planning coordination, a section later in this plan summarizes hazard priority information as it has been reported in local hazard mitigation plans. Here, it will merely be noted that civil disturbances are not currently identified as one of the most serious hazards in any of Michigan’s local hazard mitigation plans, although some communities list the hazard as significant.

Map

Michigan Department of Corrections Correctional Facilities

As of November 3, 2009



- **Correctional Facilities**

1. Ojibway Correctional Facility
2. Baraga Max. Correctional Facility
3. Marquette Branch Prison*
4. Alger Correctional Facility
5. Newberry Correctional Facility
6. Chippewa Correctional Facility
6. Kinross Correctional Facility
7. Pugsley Correctional Facility
8. Oaks Correctional Facility
9. Earnest C. Brooks Correctional Facility
9. Muskegon Correctional Facility
9. West Shoreline Correctional Facility
10. Carson City Correctional Facility
11. Mid-Michigan Correctional Facility
11. Pine River Correctional Facility
11. St. Louis Correctional Facility
12. Saginaw Correctional Facility
13. Richard A. Handlon Correctional Facility
13. Ionia Maximum Correctional Facility
13. Michigan Reformatory
13. Bellamy Creek Correctional Facility
14. Thumb Correctional Facility
15. Macomb Correctional Facility[1]
16. G. Robert Cotton Correctional Facility
16. Charles E. Egeler RGC*
16. Parnall Correctional Facility
16. Cooper Street Correctional Facility
17. Special Alternative Incarceration Facility
18. Mound Correctional Facility
18. Ryan Correctional Facility
19. Women's Huron Valley Correctional Facility*1
20. Woodland Center Correctional Facility1
21. Florence Crane Correctional Facility
21. Lakeland Correctional Facility
22. Gus Harrison Correctional Facility

*Includes reception centers
[1]Inpatient psychiatric units operated by the Michigan Dept. of Community Health

Source: Correctional Facilities Administration

NUCLEAR ATTACK

A hostile action taken against the United States which involves nuclear weapons and results in destruction of property and/or loss of life

Hazard Description

Nuclear weapons are explosive devices that manipulate atoms to release enormous amounts of energy. Compared to normal chemical explosives such as TNT or gunpowder, nuclear weapons are far more powerful and create harmful effects not seen with conventional bombs. A single nuclear weapon is able to devastate an area several miles across and inflict thousands of casualties. Although nuclear attack is an unlikely threat, the severe damage that would be caused by even one weapon requires the danger to be taken seriously.

The threat of nuclear attack has primarily been associated with the Cold War between the United States and the Soviet Union in the last half of the 20th Century. Although the Cold War is over, there remains a threat of nuclear attack. More nations have developed nuclear weapons and there is also the possibility that terrorists could use a nuclear weapon against the United States.

Hazard Analysis

Understanding Nuclear Weapons

The following information about nuclear weapons is important for understanding the threat of nuclear attack: (1) types of nuclear weapons, (2) measures of weapon power, (3) forms of attack, and (4) types of delivery systems.

Nuclear weapons have been built in a wide variety of types for several different purposes. The first weapons relied on nuclear **fission**, or the splitting of heavy atoms to release energy and create an explosion. Later, new weapons were invented that used a combination of fission and **fusion**, which involves the creation of heavier atoms from lighter ones. Fusion bombs are also referred to as **hydrogen bombs** or **H-bombs**. For emergency planning purposes, the important differences are that (1) fusion bombs are more difficult to build and (2) that they can be much more powerful. Otherwise, all types of nuclear weapons create the same types of effects.

The power of nuclear weapons is measured by comparing the energy released by the weapon to the energy released by large amounts of conventional high explosive. The strengths of smaller weapons are measured in **kilotons** (or thousands of tons) of TNT explosive. A twenty-kiloton bomb produces as much energy as twenty thousand tons of TNT exploded all at once. The strength of larger weapons is measured in **megatons**, or millions of tons of TNT. A two-megaton bomb produces as much energy as two million tons of high explosive.

Smaller nuclear weapons are generally designed to be used against military targets on the battlefield. These are called **tactical** nuclear weapons. Larger devices designed to attack cities, infrastructure, and military bases are called **strategic** nuclear weapons.

Bombs can be set off at varying heights above the target. If the bomb is set off high in the air, its effects are spread out over a wider area and generally more damage is done. This is called an **air burst**. A bomb that is set off at or near the Earth's surface level wastes much of its energy against the ground. This is called a **ground burst**. Ground bursts have some specific military uses and terrorists may use ground bursts because they are unable to lift their weapons high enough to create an air burst.

Like any weapon, a nuclear device must be carried to its target by a **delivery system**. The first nuclear weapons were bombs dropped out of aircraft. Later, tactical weapons were made small enough to fire out of cannons or carry in large backpacks. **Intercontinental ballistic missiles** (**ICBMs**) are rockets that can carry one or more nuclear weapons across thousands of miles in less than an hour. Terrorists may lack sophisticated missiles, but

they could create effective delivery systems by transporting a nuclear weapon in the back of a truck, aboard a cargo plane, or within a shipping container.

Effects of Nuclear Weapons

The effects of nuclear weapons are more complicated than those of conventional explosives. Nuclear devices cause damage through six major effects: (1) thermal pulse, (2) blast, (3) prompt radiation, (4) electromagnetic effects, (5) mass fire, and (6) residual radiation.

THERMAL PULSE is an intense flash of light and heat released within the first few seconds of a nuclear explosion. The damage from thermal pulse is almost instantaneous and covers a wide area. People and animals exposed to the pulse can be badly burned. Flammable objects such as buildings, vehicles, and trees may be set on fire. The flash is strongest close to the bomb and becomes weaker with distance. Even people located far away from the explosion may still be blinded by the intense light of the pulse.

BLAST is a powerful wave of force that moves out from the center of the explosion through the air and the ground. The farther the blast travels, the weaker it becomes. Very close to the bomb, the blast will destroy even the most strongly built buildings and will kill everyone not hidden deep underground. Farther away, buildings may survive, but with severe damage, and people will be injured by being picked up and smashed against objects. At still greater ranges, buildings will be less damaged and injuries will largely result from shattered glass and thrown debris. At all distances, a powerful wind follows the initial blast wave and adds to the destruction. The blast from a ground burst will dig a large crater into the ground, but this cratering will not occur with an air burst.

PROMPT RADIATION is the harmful blast of high energy radiation given off at the same time as the thermal pulse. Prompt radiation includes gamma rays and neutron radiation. This radiation is capable of killing or injuring living beings by damaging tissues and organs. Prompt radiation is quickly absorbed by the atmosphere and does not impact as wide an area as other nuclear weapons effects. In most instances, a person close enough to receive a harmful dose of prompt radiation is also close enough to be immediately killed by the explosion's thermal pulse or blast. However in unusual cases, some people who survive the immediate effects of the bomb may sicken or die days later, from radiation poisoning.

ELECTROMAGNETIC EFFECTS occur immediately after a nuclear explosion and may damage communications equipment, computers, and electronics. Radios, cell phones, and power lines are especially vulnerable. In most cases, the effects are limited to an area near to the explosion. Some equipment may recover after a period of time, while other devices will need to be replaced. One special type of nuclear attack might cause more widespread electromagnetic effects: a very large nuclear weapon carried high into the atmosphere by a missile is capable of damaging communications and electronics over a very large area.

MASS FIRE results from the ignition of thousands of individual fires by a bomb's thermal pulse, combined with widespread destruction from its blast. Over a period of hours, small fires merge and feed on damaged buildings and debris. Controlling these fires would be very difficult, due to damaged water mains, destroyed fire-fighting equipment, and blocked roads. The result is an extremely intense fire that can spread quickly and reach very high temperatures. Mass fire may significantly expand the area devastated by a bomb, destroying areas that might otherwise be only lightly damaged by other types of effects.

RESIDUAL RADIATION is unlike prompt radiation in that it lasts well after the nuclear explosion has ended. The ground immediately underneath the center of the explosion will be dangerously radioactive for several days due to "induced radiation." There will also be some radioactive dust and debris that will drift downwind of the explosion. This radioactive dust is called "fallout." Fallout will be a minor problem in the case of an air burst explosion, but will be very intense in the case of a ground burst attack. Regardless of the type of attack, the danger from fallout will tend to be greatest close to the site of the attack. The cloud of fallout will weaken the longer it lasts and the farther it travels.

Note that the effects of a nuclear attack will depend on the size of the weapon. A larger bomb will cause damage over a wider area. The importance of different types of damage will also vary with the weapon. Large strategic nuclear weapons will create most of their damage though thermal pulse and mass fires, while with small tactical bombs the blast effect and prompt radiation will be relatively more important.

The Nuclear Attack Threat

Nuclear attack against the United States would originate either as a strike by an enemy military or as a terrorist attack. Fortunately, nuclear devices are very difficult to build and this limits the availability of the weapons. A nuclear weapon more closely resembles a precisely built scientific tool then a simple, rugged bomb. Careful engineering and extremely rare materials are needed to make a working nuclear weapon.

At the end of World War II only the United States possessed nuclear weapons, but over time more nations have developed the necessary technology. At least eight countries now possess nuclear devices, while several more have secret nuclear weapons programs and may therefore be building bombs. While some of these "nuclear powers" are allies of the United States, others remain potential enemies. While unlikely, it is possible that an international crisis in areas such as the Persian Gulf, the Taiwan Straits, or the Korean Peninsula could escalate into an exchange of nuclear weapons. American cities are not invulnerable to attack.

There also remains a risk from accidental, mistaken, or unauthorized launch of nuclear weapons. Even the most sophisticated technology may malfunction and even the best-trained personnel may make tragic mistakes. Once a missile has been launched there is no way call it back, and a nuclear warhead fired in error will do just as much damage as one launched in anger.

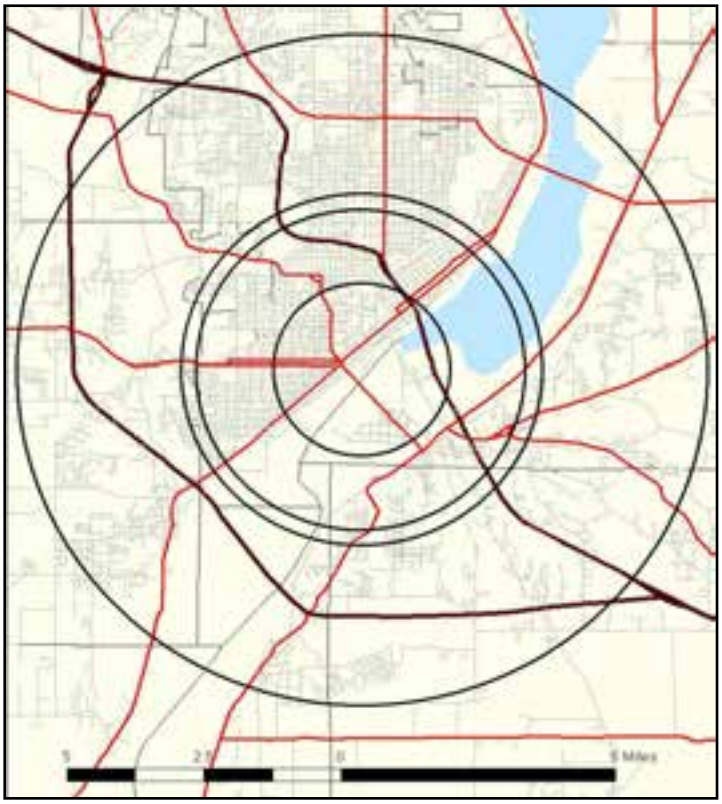
A strike by a nuclear power could consist of a single weapon or thousands, depending on the strength and intentions of the attacker. The most likely form of military attack would be the launch of intercontinental ballistic missiles fired from thousands of miles away. Although the United States now has a limited ability to shoot down incoming missiles, there are fewer than 30 interceptor missiles, of doubtful reliability. A very small attack or an accidental launch might possibly be stopped, but a larger attack would certainly strike the United States.

A nuclear power would have the ability to attack several locations at the same time. Multiple attacks across the United States would overwhelm national assets, forcing individual states or regions to rely on local resources. These attacks would probably be targeted on large cities and military bases and would use strategic nuclear weapons—each with a power of 100 kilotons or more. Cities would usually be attacked with air bursts, and military bases by the use of ground bursts.

The following map illustrates the effects of a typical military nuclear missile warhead. This example shows the effects of a 750 kiloton air-burst detonation at an altitude of 8,000 feet on a clear day above a mid-sized American city. Such an attack would be representative of an attack on Michigan cities such as Grand Rapids, Lansing, Flint, or Ann Arbor. The rings in the illustration show distances from the center of the nuclear explosion.

Outer Ring: 6.3 miles across

At this distance, the exposed skin of persons outdoors will suffer immediate 3rd degree burns (8 kcal/cm^2). With medical services destroyed or overwhelmed, almost all severely burned victims will die. Within this ring, mass fires can be expected to develop within hours. Eventually, most of this area will be destroyed by fire.



Second Ring: 3.3 miles across
At this distance, the blast wave will totally destroy light frame structures, such as most homes (5psi). Sturdier buildings will be severely damaged, with their interiors destroyed. Winds of 160mph would then follow the blast wave.

Third Ring: 3.0 miles across
At this distance, exposed persons will be affected by intense prompt radiation (5Gy). Between 50% and 80% of victims will eventually die from this exposure, unless first killed by blast or thermal effects.

Inner Ring: 1.6 miles across
At this distance, the blast wave will totally destroy even reinforced concrete buildings (20psi). Winds of 230 mph will follow the blast wave. Essentially everyone within this ring will be killed immediately.

Lighter damage will extend well beyond the area depicted in this map, mostly due to the effects of the thermal pulse.

Nuclear Terrorism
As far as is known, no terrorist organization has ever managed to gain access to nuclear weapons. However, the great destructive potential of these devices make them very desirable for terrorist groups that wish to cause massive and indiscriminate casualties. It is known that several terrorist groups have actively pursued nuclear weapons capability.

Terrorists could acquire nuclear weapons as gifts from friendly governments, by stealing them from military stockpiles, or by building a crude device on their own. Each of these approaches is considered unlikely, but not impossible. A determined and well-financed terrorist group such as Al Qaeda may eventually be able to acquire a working nuclear weapon.

A nuclear attack by a terrorist organization would likely involve only a single weapon. An attack by only a single weapon would still be a major disaster, but resources could gradually be sent from the entire United States to aid the devastated area.

Because powerful strategic bombs are more difficult to steal or build, it is likely that a terrorist device would be of the less powerful tactical type. A rough estimate for the strength of this kind of nuclear weapon would be 25 kilotons or less. Even such a ‘small’ device would be approximately as powerful as the bombs that destroyed the Japanese cites of Hiroshima and Nagasaki at the end of World War II.

A terrorist nuclear weapon would be unlikely to arrive aboard a missile. It is much more probable that the bomb would be smuggled to the target, hidden inside the back of a truck or within a cargo container. Even a bulky improvised nuclear weapon could easily be carried in this way. The bomb could be detonated from inside its hiding place, creating a nuclear ground burst. There is a lesser possibility that terrorists could use a cargo plane to deliver a nuclear weapon as an air burst.

This map illustrates the effects of a possible terrorist nuclear bomb. This example shows the effects of a 25 kiloton nuclear weapon detonated at ground level on a clear day in a mid-sized American city. Such an attack would be representative of an attack on Michigan cities such as Grand Rapids, Lansing, Flint, or Ann Arbor. The rings in the illustration show distances from the center of the nuclear explosion.

Outer Ring: 1.0 miles across
At this distance, exposed skin will suffer immediate 3rd degree burns (8 kcal/cm2). With medical services destroyed or overwhelmed, most severely burned victims will die. Within this ring, mass fires can be expected to develop within hours. Eventually, most of this area will be destroyed by fire.

Second Ring: 0.9 miles across
At this distance, the blast wave will totally destroy light frame structures, including most homes (5psi). Sturdier buildings will be severely damaged, with their interiors destroyed. Winds of 160mph would then follow the blast wave.

Third Ring: 0.8 miles across
At this distance, exposed persons will be affected by intense prompt radiation (5Gy). Between 50% and 80% of victims will eventually die from this exposure, unless first killed by blast or thermal effects.

Inner Ring: 0.2 miles across
At this distance, the blast wave will totally destroy even reinforced concrete buildings (20psi). Winds of 230 mph will follow the blast wave. Essentially everyone within this ring will be killed immediately.

Lighter damage will occur out to a distance of approximately two miles, or twice the diameter of the outer ring on the map. This damage will be caused by a combination of blast and thermal pulse effects.

The arrows in the diagram represent the area covered by a moving cloud of radioactive fallout. This cloud will drift downwind from the site of the explosion, but the size and direction of the area affected by the fallout will depend considerably on wind and weather conditions. For example, in clear weather with winds blowing at 15 miles per hour, lethal levels of radiation will be encountered several miles downwind from the site of the explosion and harmful levels will occur for up to six miles downwind. Fatalities are expected in persons

continuously exposed for four days in the contaminated area. People finding shelter or evacuated immediately will suffer substantially less harmful effects.

Note the significant differences between the two examples. The terrorist bomb directly impacts a much smaller area, but it creates a dangerous cloud of radioactive fallout. The lethal thermal pulse from the air burst missile explosion covers an area much greater than the area of heavy blast damage, while in the case of the terrorist bomb those two effects are more equal. In the case of the missile explosion, the area of effect for prompt radiation is much smaller than that for blast and thermal effects, but in the case of the terrorist bomb, lethal radiation extends almost as far as the other effects.

Global Consequences of Nuclear Attack

A final consideration for the nuclear attack hazard is the impact of a nuclear attack outside of Michigan's borders. An attack elsewhere in the United States or elsewhere in the world would have serious negative economic consequences. Such an attack would also result in a global call for emergency response resources, including those in Michigan. Finally, a large scale nuclear war involving many nuclear weapons could have damaging effects on climate worldwide. A nuclear attack would have serious consequences for Michigan, regardless of where that attack occurred.

Impacts of Nuclear Attack

Impact on the Public

A nuclear attack would cause catastrophic damage over a wide area. Attacks on populated areas would inflict massive loss of life, destruction of property, environmental damage, infrastructure failure, and public health impacts. In the case of a ground burst weapon, some areas would remain uninhabitable for an extended period of time. A nuclear war, even if occurring far from the United States, would have serious economic and environmental consequences, resulting in additional harm to the public. Although unlikely to occur, nuclear attack potentially poses a very great threat in terms of fatalities, property damage, and size of impact area.

Impact on Public Confidence in State Governance

Public confidence in state government following a nuclear attack is difficult to predict. It is likely that public reaction would depend on the perceived effectiveness of government response to the disaster. Given the extensive damage caused by nuclear weapons, and the limited available resources, it is very likely that government services would be overwhelmed. An especially serious problem would be insufficient medical resources for the treatment of injured victims. It is conceivable that the unmet needs of survivors could result in a significant loss of confidence in state government. On the other hand, anger at the perpetrators of the attack and feeling of patriotic solidarity might increase popular support of government, at least in the short term.

Impact on Responders

A nuclear attack would pose extensive risks and challenges for responders. In any attack on a populated area, many responders would be immediately killed or injured in firehouses, police stations, hospitals, etc. affected by the explosion. Surviving responders would face serious and unfamiliar challenges, including widespread infrastructure failure, high levels of radiation, mass urban fires, and the disruption of command and communications systems. Responders would also face an unprecedented level of need from thousands of injured or dying citizens. In the short term, emergency resources would unavoidably fall far short of requirements. Help could only be provided to a limited percentage of the total number of victims. Extensive casualties would be expected among responders. In the long term, responders and emergency managers would face massive challenges in sheltering, evacuation, medical care, and public order.

Impact on the Environment

A nuclear attack would cause significant environmental damage. In addition to the immediate destruction from blast and thermal effects, continuing damage would be expected due to toxic smoke clouds from mass urban fires, hazardous materials released from damaged storage facilities, and waste from wrecked water treatment systems.

Radioactive contamination would occur, with the extent depending on the specific details of the attack. At worst, large areas would be poisoned by fallout, and a crater at the site of an explosion could remain heavily contaminated for years. Use of numerous nuclear weapons might cause environmental damage on a regional or global scale, far beyond the effects created by a single weapon or small number of weapons. Such damage could occur during an extensive nuclear war. Specific effects would depend on the size and number of weapons used, as well as their specific targets. Global environmental impacts might include a drop in global temperature, reductions in food production, damage to the Earth's protective ozone layer, and an increase in background radiation levels.

Additional Nuclear Attack Guidance Information

During the Cold War, the nuclear attack hazard was not customarily analyzed at the local level. The large numbers of weapons available to the United States and Soviet Union threatened destruction on an enormous scale, and few plans could attempt to adequately address the hazard. Even communities not directly attacked would have been profoundly or fatally impacted by the effects of a superpower exchange.

Today, the threat of nuclear attack is very different, and local planning may again be appropriate for this hazard. The possibility of attack still exists, but the principal threat is the use of an individual nuclear weapon or a small number of weapons. Cold War planning scenarios may need to be updated to reflect the fact that the nature of the threat has changed. Not only are there far fewer nuclear weapons than in past decades, but the individual weapons are, for the most part, far less powerful.

When considering the hazard of nuclear attack by a foreign power, local vulnerabilities would be assessed in terms of proximity to possible high-priority targets. These might include military bases, large power plants, oil refineries, and major population centers. Targets identified in Cold War plans may no longer be relevant, as closed military bases and shut-down power plants are no longer likely targets. Since there is no way to accurately assess the probability of nuclear war, most mitigation strategies would be prompted by, and originate from, federal initiatives and defense priorities. The "risk" part of a local hazard analysis on this topic would therefore probably be missing, due to lack of information, but the "vulnerability" portion can still be assessed in terms of the presence of potential targets.

Also worthy of consideration is the possibility that one or more nuclear weapons might be used in an attack by a terrorist organization, especially in light of the ongoing threat posed by international terrorist groups. The section of this plan dealing with Terrorism and Similar Criminal Activities should be freely referred to, particularly in regards to potential terrorist targets. When planning for a terrorist nuclear attack, consider that the effects of a terrorist weapon are likely to be very different than those caused by a nuclear missile attack.

For any nuclear attack planning, the presence of fallout shelters, or makeshift substitute shelters, might be a key factor of analysis. When considering mitigation and response strategies, the ability to shelter or evacuate people would clearly be important. The ability to maintain government functions and social services would be similarly important. Protection of critical computer and communications systems from the effects of electromagnetic pulse would also be worth considering. The presence of redundancies (backup systems) in an area's infrastructure and critical services would be another means to assess local vulnerability to a nuclear attack.

Summary

Nuclear attack is an unlikely hazard, but even a single weapon could cause death and destruction on a massive scale. Nuclear weapons inflict damage over a wide area and through a variety of effects, including thermal pulse, blast, fire, and radiation. Despite the end of the Cold War, nuclear attack by foreign nations remains a real possibility, and this danger has been joined by the threat of terrorist nuclear attack. It makes sense to continue to prepare for the nuclear attack hazard as part of an overall emergency management strategy.

Hazard Mitigation Alternatives for Nuclear Attack

- Designated fallout shelters and public warning systems.
- Construction of concrete safe rooms (or shelters) in houses, trailer parks, community facilities, and business districts.
- Using laminated glass, metal shutters, structural bracing, and other hazard-resistant, durable construction techniques in public buildings and critical facilities.
- Increased coverage and use of NOAA Weather Radio (which can provide notification to the community during any period of emergency, including enemy attack).

Tie-in with Local Hazard Mitigation Planning

Because many means of implementing mitigation actions occur through local activities, this updated MHMP places additional emphasis on the coordination of State-level planning and initiatives with those taking place at the local level. This takes two forms:

1. The provision of guidance, encouragement, and incentives to local governments by the State, to promote local plan development (including a consideration of drought conditions), and
2. The consideration of information contained in local hazard mitigation plans when developing State plans and mitigation priorities.

Regarding the first type of State-local planning coordination, MSP guidance has included the "Local Hazard Mitigation Planning Workbook" (EMD-PUB 207), which is currently being updated for release by 2015. For the second type of State-local planning coordination, a section later in this plan summarizes hazard priority information as it has been reported in local hazard mitigation plans. Here, it will merely be noted that nuclear attack was identified as one of the most significant hazards in the local hazard mitigation plans for Cass and Huron counties.

This hazard is not one whose risks have customarily been analyzed at the local level. During the Cold War, the policy of "mutually assured destruction" meant that even communities that had no direct targets anywhere within their vicinity would nevertheless be profoundly or fatally impacted by the massive and wide-scale effects of a full nuclear exchange between the United States and Soviet Union. The effects of being struck by as many as 3,000 warheads (each of which would be much more powerful than the atomic blasts seen at Nagasaki and Hiroshima) would mean an almost inconceivable change in world conditions that few plans could attempt to adequately address. With the end of the Cold War period, local planning may again be appropriate for this hazard. The possibility exists of being selectively targeted by a hostile nation or group that has both nuclear arms <u>and</u> the ability to deliver such devices to a target in Michigan.

The newest nuclear threats concern the possibility that one or more nuclear weapons might be used in an attack by international terrorist groups, or the activities of domestic actors, who might eventually be able to acquire and misuse nuclear technologies and detonate a device within our country. The risks from such scenarios are worth considering in light of new Homeland Security concerns and in the context of the War on Terror. The section dealing with Terrorism and Similar Criminal Activities should be freely referred to. Many Cold War scenarios may need to be updated to reflect the fact that some identified targets may no longer have military significance and thus would no longer have a reason to be deliberately targeted.

The presence of fallout shelters, or makeshift substitutes for them, might be a form of hazard mitigation, to protect an area's residents. In addition, the ability of current transportation systems to handle mass evacuations could be another critical factor in reacting to a threatened or impending nuclear detonation. The presence of redundancies (backup systems) in an area's infrastructure and critical services could be another means to increase local resilience to a nuclear attack.

PUBLIC HEALTH EMERGENCIES

A widespread and/or severe epidemic, incident of contamination, or other situation that presents a danger to or otherwise negatively impacts the general health and well-being of the public.

Hazard Description

Public health emergencies can take many forms—**disease** epidemics, large-scale incidents of food or water **contamination**, extended periods without adequate water and sewer **services**, harmful exposure to chemical, radiological or biological agents, and large-scale infestations of disease-carrying insects or rodents, to name just a few. Public health emergencies can occur as primary events by themselves, or they may be secondary events to another disaster or emergency such as a flood, tornado, or hazardous material incident. The common characteristic of most public health emergencies is that they adversely impact, or have the potential to adversely impact, a large number of people. Public health emergencies can be statewide, regional, or localized in scope and magnitude.

Perhaps the greatest emerging public health threat would be the intentional release of a radiological, chemical, or biological agent with the potential to adversely impact a large number of people. Such a release would most likely be an act of sabotage aimed at the government or at a specific organization or segment of the population. Fortunately, Michigan has not yet experienced such a release aimed at mass destruction. However, Michigan has experienced hoaxes and it may only be a matter of time before an actual incident of that nature and magnitude does occur. If it does, the public health implications—under the right set of circumstances—could be staggering.

Hazard Analysis

Michigan has had several large-scale public health emergencies in recent history, but fortunately nothing that caused widespread severe injury or death. The 1973 PBB contamination incident is unprecedented in U.S. history, but the long-term implications of contamination may be less than was feared. Similarly, the northern Michigan water and sewer infrastructure disaster of 1994 is also unprecedented in scope, magnitude, and public health and safety implications for the affected communities. These events, though unusual, have heightened awareness of the broad nature of threats that can result in a public health emergency. Such emergencies no longer simply involve the spread of disease, but rather can arise out of a variety of situations and circumstances.

In 2001, Michigan health officials were introduced to the emerging health threats posed by foot-and-mouth disease and the West Nile encephalitis virus. Although foot-and-mouth disease is a highly contagious disease that only affects animals, a widespread outbreak such as that which occurred in parts of the United Kingdom in the spring of 2001 could have significant public health implications for humans as well, due to the potentially large numbers of dead animal carcasses that would have to be disposed of to prevent disease outbreaks. The Michigan Department of Agriculture and Rural Development, in conjunction with numerous other federal, state and local agencies and the agriculture industry, continues to monitor the foot-and-mouth disease situation and take the necessary steps to prevent the introduction and spread of the disease in the United States.

The West Nile encephalitis virus, which arrived in Michigan in August 2001, presents an equally challenging scenario for public health officials. Transmitted to humans by the bite of an infected mosquito, the West Nile virus is commonly found in Africa, West and Central Asia, and the Middle East. Health officials do not know how the virus was introduced to the United States. However, in 1999 and 2000, it caused an outbreak of human encephalitis in and around New York City that created a national stir and raised fears across the country that it would cause a full-blown public health emergency. The virus eventually spread to Michigan in 2001. It peaked in Michigan in 2002 with 644 reported cases, including 51 deaths. There has been a decline in reported cases every year since then.

Although no area in Michigan (or elsewhere) is immune to public health emergencies, areas with high population concentrations will always be more vulnerable to the threat. In addition, the more vulnerable members of society—the elderly, children, impoverished individuals, and persons in poor health—are also more at risk than the general population.

Michigan is fortunate in that it has an excellent public health system that constantly monitors the threats that could lead to a widespread or significant public health emergency. However, even the best monitoring and surveillance programs cannot always prevent such incidents from occurring. When they do occur, Michigan's public health agencies have shown the ability to effectively muster the resources necessary to identify and isolate the problem, and mitigate its effects on the population. In addition, if the problem is such that a multi-agency and multi-jurisdictional response is required, the emergency management system in Michigan can be utilized to enhance coordination and effectiveness of the response and recovery effort.

Impact on the Public

The primary types of public health impacts involve the threat or presence of either disease, contamination, or sanitation problems. Disease epidemics or pandemics have the potential to cause widespread debilitation or loss of life, associated medical expenditures, and decreases in productivity and quality of life. Contamination can at least temporarily lower property values, as well. Sanitation problems require effort and expense to resolve. Contamination and sanitation issues increase the probability and variety of diseases that may affect the population. Facilities may be shut down, as a means of preventing disease transmission or of containing contamination, and thus cause a loss of the services being provided to the public (by schools, for example). Medical resources may become overwhelmed and unable to deal with any additional needs. As traditional medical services become increasingly difficult to access (or if their quality declines due to overwork or understaffing) then increasing numbers may turn to less responsible and effective alternative means of treatment (or may forego treatment entirely).

Impact on Public Confidence in State Governance

The PBB incident of the mid-1970s caused part of the population to perceive a "cover up" by the state, or suspicions of faulty research involving the amount and nature of PBB risks. Although it took time for the cause and nature of the incident to be understood, and the detection of long-term health risks from PBB eventually became clearer, the public and the mass media's understanding of the nature of scientific research tends to be prone to misjudgments, hasty conclusions, and an abundance of speculation.

Food-borne illnesses, including the contamination of products during manufacture, is another type of public-health emergency that is likely to be associated in the public mind with the effectiveness of government policies and regulatory agencies. Widespread illness that is associated with public infrastructure (e.g. water, sewer, electrical) or with conditions that are overseen by government inspectors (e.g. air conditioning and ventilation systems) are more likely to cause a loss of public confidence in government when it occurs. Maintenance-related and environmental issues that may affect public health in an area (such as urban blight and insect/rodent infestations, contaminated brownfield sites, scrap tire piles, industrial or nuclear accidents) are also ones for which some level(s) of government will be held accountable by the media and the public. Post-disaster conditions that allow the spread of illness (or the breakdown of public health services) will also have a great potential to cause dissatisfaction with and loss of confidence in government.

There are also cases (e.g. a cluster of lethal meningitis infections on a large university campus) in which the public is unfamiliar with epidemiological methods and data, and believes that a problem exists despite government assurances that there is not yet sufficient evidence to reach that conclusion. The result would be that, unless offsetting information is proactively provided to the public, various persons will feel that abstract analysis techniques (or bureaucracy) are preventing government workers from seeing conditions that certain citizens consider to be "obvious." This mismatch in understanding and perception often results in citizen criticism of "government."

Impact on Responders

The primary types of emergency public health concerns involve the threat or presence of either disease, contamination, or sanitation problems. Certain types of contamination issues are similar to hazardous materials (q.v.) in their impact on responders, in that special measures, expertise, and precautions may be required when dealing with an incident. A similar approach may be taken with sanitation issues, in which special crews may need to be called in to deal with the problem, and the measurement and monitoring of the problem may require specialized equipment and expertise. On the other hand, issues of contagious disease tend to call for different response and precaution procedures, since there are many human-related transmission vectors that can seem more diffuse and unclear. Unless special training and equipment is obtained and employed, responders may be found to have an increased risk of succumbing to the contagious illness being responded to. (Even with the use of equipment and training, responders may still be more at risk, due to increased exposures to bacterial and viral threats.)

Impact on the Environment

A public health emergency tends to primarily affect people, but in a severe, large-scale event, decontamination centers, quarantine buildings, or additional medical facilities might need to be developed quickly, disregarding land use laws. This type of development may result in the loss of an area's natural wildlife habitat and could also impact the environment by causing nearby properties to flood.

Significant Public Health Emergencies

This is a list of brief synopses of some of the more significant public health emergencies that have occurred in Michigan during recent years. (It does not include communicable disease outbreaks, which are covered later in this chapter.)

1970s to Present Eastern Michigan Dioxin and PCBs

The Saginaw watershed—including the Tittabawassee River (and floodplain) downstream of the City of Midland, the Saginaw River, and Saginaw Bay—is contaminated with dioxin and polychlorinated biphenyls (PCBs) as a result of industrial processes. These contaminants can cause health effects in humans, and may be carcinogenic. Multiple state and federal agencies have been and continue to be involved with assessing the effects of exposure in humans and animals, and studying environmental clean-up issues. In 2005, news media reported that an environmental firm had discovered a pool of PCBs under some sewer lines in St. Clair Shores, with concentrations that were "200,000 times above safe levels." It was reported that more than $7 million had been spent since 2002 in canal clean-up near Lake St. Clair.

1973 Chemical Contamination (Polybrominated Biphenyl Contamination)

One of Michigan's most serious statewide public health emergencies occurred in 1973 when a chemical company inadvertently sent bags of a fire retardant containing polybrominated biphenyl (PBB), a highly toxic chemical, along with a shipment of livestock feed supplement to Michigan Farm Bureau Services. After being mixed with the livestock feed, the contaminated mixture was distributed statewide for use by farmers in feeding livestock herds. The result was an environmental and public health disaster of unprecedented magnitude in Michigan. Thousands of cattle and other animals died from the poisoning and serious questions were raised regarding the long-term effects of this contamination on all Michigan residents.

1977 Oakland County Foodborne Pathogenic Contamination (Botulism Outbreak)

In 1977, the worst outbreak of botulism in U.S. history was linked to home-canned jalapeno peppers served by an Oakland County restaurant. (Botulism is caused by a bacterium that grows from spores in an atmosphere without oxygen. Improperly canned foods are a primary source of the botulism bacterium. Botulism attacks the neuromuscular system and is one of the most dreaded of food poisoning agents, with a high mortality rate.) The restaurant used 200 jars of home canned peppers because a crop failure the preceding winter had created a shortage of commercially prepared peppers. Fifty-nine (59) restaurant patrons reportedly fell ill from the botulism poisoning, though no one died. Many of those affected required intensive care level treatment and horse serum botulism antitoxin. (Note: The supply of horse serum botulism antitoxin is limited, and it must be transported from regional depots to a hospital that has need of it. Because the amount of toxin required to paralyze a person is so low, the potential for a very large botulism outbreak always exists.)

Spring 1994 Northern Michigan Loss of Water and Sewer Service

A breakdown of critical water and sewer infrastructure can (if not immediately abated) result in a public health emergency for the affected area. That is exactly what happened in the early spring of 1994 in northern Michigan, when over 3,200 water and sewer lines broke or became frozen due to unusually deep subterranean frost depths. The emergency conditions were present in some locations for up to 5 months. As a result, many communities had to provide shelter for those residents without water and/or sewer service for an extended period of time. In addition, boil-water advisories were issued in many communities, due to the potential for water contamination from lack of adequate system pressure. Fire safety hazards were also prevalent, due to the lack of adequate system pressure, as well as the fact that many homeowners were using improper equipment to thaw out frozen water and sewer lines (sometimes starting fires in the process).

Because of the public health and safety risks associated with this unusual event, as well as the millions of dollars in physical damage caused to this vital infrastructure, Michigan was granted a Presidential Disaster Declaration in May, 1994. That declaration allowed for the immediate repair, restoration and/or replacement of the damaged water and sewer infrastructure. By the middle of summer, most of the repair work had been completed, thus bringing to a close one of Michigan's (and the nation's) most unusual public health emergencies.

Spring 1997 Michigan Foodborne Pathogenic Contamination (Hepatitis A Outbreak)

In the spring of 1997, almost 300 cases of hepatitis A occurred in at least four Michigan school districts. A rapid epidemiological investigation by local, state and federal epidemiologists linked this outbreak to frozen strawberries distributed through the national school lunch program. Tracing of the implicated strawberries identified 13 different lots sent to several states in addition to Michigan. Several hundred Michigan schools were potentially affected. A massive program was instituted to evaluate risk at schools that received the frozen strawberries, to inform parents about immune globulin prophylaxis, and to provide it to recently exposed children. The prompt and insightful epidemiological investigation and rapid, well-organized response of the Michigan local health department system helped to prevent the occurrence of additional illnesses and to reduce community anxiety.

Aug. 1998 – Feb. 1999 Multi-state outbreak Foodborne Pathogenic Contamination (Listeriosis Outbreak)

2002 Nationwide outbreaks Foodborne Pathogenic Contamination (Listeriosis Outbreak)

A multi-state outbreak of Listeriosis, from August 1998 to February 1999, had its origin at a Bil Mar Foods meat plant in Zeeland. (Listeriosis is caused by the foodborne bacterium Listeria monocytogenes—commonly called Listeria—that can cause serious illness and death to pregnant women, newborns, older adults, and persons with weakened immune systems.) Health officials identified the vehicle for transmission of the Listeria bacterium as hot dogs and deli meats produced at the plant under numerous brand names. The exact source of the contamination was not determined. A total of 21 deaths and 100 illnesses nationwide had been linked to the contaminated meats. In December, 1998, 35 million pounds of hot dogs and deli meats were voluntarily recalled by the manufacturer—the largest meat recall in U.S. history. Once the recall was instituted, the number of illnesses caused by the outbreak decreased dramatically. The Zeeland plant was allowed to resume meat production in March, 1999, after more stringent food safety procedures were implemented. In 2002, at least 40 persons were sickened and 10 were killed in a nationwide listeria outbreak linked to the meat company Pilgrim's Pride Corp. The company then recalled 27.4 million pounds of meat, after tests at a Pennsylvania plant revealed strains of Listeria monocytogenes that matched the outbreak strain.

1999-present Statewide West Nile Virus

The West Nile virus is a mosquito-borne virus that can cause encephalitis (inflammation of the brain) and meningitis (inflammation of the lining of the brain and spinal cord). Outbreaks of the disease caused by the West Nile virus have occurred in Egypt, Asia, Israel, South Africa, and some parts of Europe and Australia. The virus was first seen in the U.S. in the fall of 1999 in New York City, and has since spread across the U.S. to the Pacific Ocean, into several Canadian Provinces, and possibly into Mexico. The virus was first detected in Michigan in 2001 and has been detected in Michigan each year since then. The virus peaked in Michigan in 2002, when 644 human cases were reported, including 51 deaths. In 2003, human cases in the state dropped to 19, with no fatalities. In 2004, 16 human cases, none fatal, were reported in Michigan. The West Nile virus lives in birds and other animals, and mosquitoes can transfer it from the animals to humans. Seniors, infants, and people with weakened immune systems are most vulnerable to West Nile and most likely to become seriously ill from it. Experts urge residents to monitor the birds in their yards, especially when one dies.

November, 2000 Cadillac Foodborne Pathogenic Contamination (Salmonella Outbreak)

In early November 2000, a salmonella poisoning outbreak in Cadillac killed one person and sickened 17 others. Health officials were able to trace the likely source of the poisoning back to a caterer who provided food to four events on November 4. The suspected food item was served at the two events where people became ill, but not at the other two events.

March 2002 Clinton Township Foodborne Pathogenic Contamination (Salmonella Outbreak)

In March 2002, a salmonella poisoning outbreak in Clinton Township hospitalized at least 10 people. The source of the poisoning was traced backed to pastries at a local bakery. As many as 60 people may have eaten the pastries in one of Macomb County's worst outbreaks of salmonella poisoning. Many of the customers were sick in bed for several days after consuming the pastries.

Sept. 2002 Farmington, MI Legionnaires Disease

In September of 2002, four people were killed and 30 others became ill from an airborne bacteria in vapor emitted from an air conditioning cooling unit at a grocery store in Farmington. It was also reported that at least 16 people were sickened by the disease in Vermont around the same time. Legionnaires disease is spread when people inhale mist carrying the bacteria. People infected with the bacteria may develop pneumonia-like symptoms and high fevers within two weeks of exposure. The disease can be fatal, especially to the elderly, people with weakened immune systems, and children.

May, 2003 Byron Center, MI Food Tampering

In one of the nation's largest reported cases of food tampering, a former supermarket employee admitted to poisoning about 250 pounds of the store's ground beef with insecticide, sickening at least 92 people who ate the meat. The employee had a dispute with a co-worker and had put the insecticide in the meat in an attempt to get him in trouble. The insecticide he used had a high concentration of nicotine as its active ingredient, and swallowing it could be fatal. The disgruntled employee poured the insecticide on the ground beef as he prepared it and packaged the poisoned meat.

2008 Multiple States Foodborne Pathogenic Contamination (Salmonella Outbreak)

In November 2008, Michigan joined a rapidly expanding investigation of a nationwide outbreak of Salmonella Typhimurium, which ultimately exceeded 700 cases from 46 U.S. States and from Canada. A total of 38 confirmed cases with onset dates between October 2008 and February 2009 were identified in Michigan from 15 widely dispersed counties in the lower peninsula of the State. Of these, there were 12 reported hospitalizations. Two unusual features of both the Michigan and nationwide outbreak were noted very early in the investigation—the predominantly young distribution of the cases and the high frequency of exposure in institutional settings such as elementary schools, colleges, long term care facilities, and correctional centers.

November 2008 Holland, MI Norovirus Outbreak

About 420 Hope College students, faculty, and staff reported coming down with an illness from a noro-like virus in November 2008. Symptoms included diarrhea, nausea, and vomiting for 24 to 48 hours. The outbreak prompted the school and county health officials to close the campus and cancel activities starting November 7th, with students who stayed on campus restricted from gathering. Campus security and Holland police were asked to break up any parties or other student gatherings both on and off campus. The campus reopened four days later on November 11th and students were given a bag with plastic gloves, disposable wipes and bleach-based cleaning spray for sanitizing their rooms. Hand sanitizer dispensers were placed in about 40 locations on the Hope College campus to aid in the attempt to stop the spread of the norovirus outbreak.

Spring 2009 East Lansing, MI Foodborne Pathogenic Contamination (E-coli Outbreaks)

In spring 2009, Michigan State University faced a food poisoning outbreak that closed a campus dining hall. Over 50 people were stricken with a stomach illness. About 28 students reported symptoms that included diarrhea, vomiting, nausea, and stomach pain, and were treated at a local hospital. Approximately 30 other students were treated at the student health center. During the fall semester at MSU, dozens of cases of E. coli, all containing the same genetic fingerprint, were reported and linked to contaminated lettuce from large commercial bags sold by Aunt Mid's. Twenty-one people were hospitalized, with one developing HUS, or hemolytic uremic syndrome, a type of kidney failure linked to food poisoning.

Spring 2010 South East Michigan Foodborne Pathogenic Contamination (Campylobacter)

Thirteen patients fell ill around the same time, with fever and diarrhea later confirmed to be caused by bacteria in raw milk, a food-borne contaminant called campylobacter illness. The suspect milk was distributed to members of a farm cooperative in Vandalia, and not sold in grocery stores.

Federal health officials estimate that 76 million illnesses, 325,000 hospitalizations, and 5,000 deaths occur in the United States each year due to foodborne diseases. Food safety is complicated by the fact that Americans eat out more often and eat more processed foods, both of which involve more potential exposure to food handling errors. In addition, the number of persons who are more vulnerable to foodborne diseases (those with weakened immune systems, the elderly) continues to increase over time.

Other Public Health Events and Conditions of Significance

2003 Washington Foodborne Pathogenic Contamination (Mad Cow Disease)

2004 Texas Foodborne Pathogenic Contamination (Mad Cow Disease)

Mad Cow Disease is the name commonly used for Bovine Spongiform Encephalopathy (BSE), a slowly progressive, degenerative, fatal disease affecting the central nervous system of adult cattle. In humans, a rare and deadly form called variant Creutzfeldt-Jacob disease has been linked to eating infected tissue from cows. Mad Cow disease in Britain in the 1980s and 1990s had been blamed for the deaths of 150 people. Fortunately, there has never been a documented case of the human illness from the eating of contaminated beef in the United States. Since 1990, the U.S. Department of Agriculture (USDA) has conducted aggressive surveillance of the highest risk cattle going to slaughter and 10,000 to 20,000 animals per year have been tested. The only documented case of the brain-destroying disease in U.S.-born and raised livestock was discovered in 2004, in Texas, just days before Independence Day, one of the major grilling weekends of the year. The only other case of the disease in the United States turned up in 2003 in Washington state, in a dairy cow that had come from Canada. As soon as the BSE cases were identified, both the USDA and FDA had activated their BSE Emergency Response Plans and the USDA immediately recalled the meat. Meat that did enter the food supply was quickly traced and removed from the marketplace.

Various dates and locations VRSA and VISA

Staphylococcus aureus is a bacteria commonly found on the skin and in the nose of healthy people. It can occasionally get into the body, with the potential to cause serious, life-threatening blood infections or pneumonia. Staph aureus infects about 400,000 U.S. hospital patients a year, killing about one-quarter of them. VISA (Vancomycin-Intermediate Staphylococcus Aureus) or VRSA (Vancomycin-Resistant Staphylococcus Aureus) are specific types of antimicrobial-resistant staph bacteria. While most staph bacteria are susceptible to the antimicrobial agent vancomycin, some have developed resistance. VISA and VRSA can no longer be successfully treated with vancomycin.

Various dates and locations Radon (See Michigan map at the end of the section)

Radon is a colorless, odorless, radioactive gas that is created naturally by the breakdown of uranium and radium. Radon gas is continuously released from rocks and soil containing these two elements. Uranium and radium may be found in almost all soil and rock, but are most often associated with those containing granite, shale, and phosphate. The Surgeon General has declared radon exposure to be the second leading cause of lung cancer deaths in the United States, after smoking. Exposure to natural radon is estimated to be responsible for 7,000 to 30,000 lung cancer deaths each year in the United States. As with other forms of cancer, lung cancer resulting from exposure to radon may develop over many years before it is diagnosed.

Various dates and locations Fecal-Oral Contamination (Viral, e.g. Norovirus)

Gastroenteritis caused by viruses is becoming a greater public health threat. These viruses are easily transmittable, are not treatable by antibiotics or anti-virals, and can survive on surfaces for long periods of time. Hospitalization and death can be likely if persons suffering from infection-caused dehydration are not promptly treated. Outbreaks can be difficult to contain if proper hygiene practices are not implemented.

Since September 2008, 172 norovirus outbreaks have been reported to the MDCH, with a total of 5,065 persons reported ill. One hundred and six of the reported outbreaks occurred at healthcare facilities, hospitals, nursing homes, and long-term care facilities. Thirteen outbreaks were related to restaurants or catering facilities, and 30 outbreaks occurred at universities, schools, and day-care centers.

Communicable Disease Epidemic (Influenza Pandemics)

There have been several communicable disease outbreaks or epidemics, or the potential for such threats, which can be classified as public health emergencies. One of the principal dangers of communicable disease outbreaks is that they can rapidly overwhelm the local health care system.

Influenza is an example of a potential public health emergency of very large proportions. No one knows when the influenza virus might “shift” its structure to produce a virus to which no one will be immune. Influenza can exact a terrible toll on communities. During a typical influenza season, approximately 1,188 deaths in Michigan are expected. However, during the next influenza pandemic (a worldwide epidemic), as many as 10 to 100 times that many might die, without an adequate and well-organized public/community health care system to combat the disease. As hard as the world public health community is trying to conduct influenza surveillance in order to provide the most advance notice possible, if pandemic influenza were to strike it would likely do so very early in the season and spread so rapidly that preparation would need to be done on an emergency basis.

In the northern hemisphere, the normal flu season starts in November and ends in May. Flu viruses are amenable to chilly weather, and therefore predominate around the winter season in temperate climates. (Contagion may also be assisted by persons spending more time in indoor areas with less ventilation from outside.)

Background On Influenza Pandemics

The world's worst influenza pandemic—the "Spanish flu" of 1918-19—resulted in 500,000 to 675,000 deaths in the United States and 20 to 40 million worldwide. More than 25 million Americans—nearly one quarter of the population at the time—fell ill. Scientists speculate that the virus that caused that pandemic may have percolated for several years within humans, or possibly pigs, until it grew strong enough to kill millions worldwide. The virus spread rapidly—moving around the world in a matter of a few months—in a time period in which there was much less movement of people than there is today. The virus reached Michigan in the fall of 1918. Over 8,000 of the 2.8 million state residents fell ill and half of those eventually succumbed to the disease. In retrospect, the spread of the illness was felt to be exacerbated by behavior of important officials who had misguided concerns that the effects of "panic" might be more harmful than the disease itself—a notion that proved disastrous. The pandemic had an unusual aspect, however, in that many of those who died were persons who had been young and healthy, whereas the normal pattern for influenza deaths is to take a higher toll among those who are elderly or have compromised immune systems.

(Note: As a sheer numerical comparison, the 1918-19 influenza pandemic worldwide death tolls came close to equaling the death tolls of the medieval Black [Bubonic] Plague that struck in the 6th, 14th, and 17th centuries. The number of U.S. deaths from the pandemic exceeded the number of U.S. soldiers killed on the battlefield in World Wars I and II, the Korean War, and the Vietnam War combined.)

Two other major influenza pandemics occurred during the 20th century—the 1957-58 "Asian flu" that killed 70,000 in the United States, and the 1968-69 "Hong-Kong flu" that resulted in 34,000 U.S. deaths—each spreading with the same rapidness as the 1918-19 pandemic. The possibility is always there that another pandemic could occur at any time. The speed and frequency of modern global travel could greatly exacerbate the spread and potential impacts of future pandemics, forcing public health officials to race against the clock to prevent the death tolls experienced in past pandemics.

Influenza viruses are designated with letters and numbers. Three main groups exist (A, B, and C), and Influenza A contains those viruses that have the capacity to cause human pandemics. Within that main classification are more specific letter-number designations that specify two types of proteins on the outer part of the virus—hemagglutinin (H) and neuraminidase (N). There are 16 known types of H and 9 known varieties of N, and combinations of these protein types distinguish various strains of the Influenza A virus from each other. As of 2009, only three combinations—H1N1, H2N2, and H3N2—have been involved in viruses confirmed to spread directly from person to person. However, it is possible for other virus strains, such as those found in birds or swine, to change and become capable of infecting other species. In 1976, a swine flu outbreak occurred among humans stationed at the Fort Dix military facility in New Jersey, and was addressed with a mass vaccination program, although the vaccine itself was found to have a small (1 in 100,000) risk of causing the serious Guillain-Barré syndrome.

In 2005, an outbreak of influenza A (H5N1), also known as "avian flu" or "bird flu," was reported in several countries throughout Asia. First identified in 1997 Hong Kong, cases of avian influenza A (H5N1) in birds were later confirmed in Cambodia, China, Hong Kong, Indonesia, Japan, Laos, Pakistan, South Korea, Thailand, and Vietnam. Human cases of avian influenza were reported in Thailand and Vietnam. In an investigation, it was not determined that the avian flu was spread from person to person. The outbreak of avian influenza prompted the killing of more than 25 million birds in Asia. This strain of avian influenza A (H5N1) was not found in the United States. However, in February 2004, different strains of avian flu were detected among several flocks of birds in the U.S., and state officials ordered the destruction of hundreds of thousands of birds. The avian influenza strain found in Delaware was H7N2, in Pennsylvania the strain was H2N2, and the H5N2 strain was

found in Texas. The strain found in Texas was determined to be "highly pathogenic" to birds. However, the strain of avian influenza in Texas was not the same as the strain in Asia.

The World Health Organization (WHO) announced a substantial risk of an influenza epidemic in the near future. One of the primary concerns is that the virus could quickly spread across the World. In response, many countries have begun planning in anticipation of an outbreak. During the spring of 2009, a new influenza virus was identified. Studies showed that this new virus was different from what had normally circulated throughout the world. Humans are expecially vulnerable because their immune systems had not been previously exposed to this virus, therefore allowing limited immune response. H1N1 (also called "swine flu," in this case) has exhibited atypical presentation in human populations. Over 90% of detected cases are in persons under 65 years of age. In comparison to other flu viruses, hospitalizations and deaths associated with H1N1 are dramatically higher in children and young adults. Also of concern, the virus has demonstrated the ability to develop resistance to anti-viral medications. Thousands of cases of influenza-like illness were reported in Michigan during the last week of October 2009 alone. However, according to an Associated Press wire report (of September 29, 2010) regarding CDC recent studies, that strain of the "swine flu" no longer represented a major threat in the United States because most citizens came to show signs of immunity.

Communicable diseases can be transmitted by any of a variety of mechanisms, including droplets from coughs and sneezes, insect bites, contaminated water or food, or other vectors. Epidemiology is the study of the distribution and determinants of disease in human populations and the application of this study to control health problems. The following table explains a few epidemiology terms that may be helpful in understanding the spread of disease.

Epidemiology Terms	
Epidemic	The occurrence of more cases of a disease than would be expected in a community or region during a given time period.
Pandemic	An epidemic that becomes very widespread and affects a whole region, a continent, or the world.
Endemic	Present in a community at all times but in relatively low frequency. Something that is endemic is typically restricted to, or peculiar to, a locality or region.
Zoonosis	An infectious disease that may be transmitted from (wild and domestic) animals to humans.

There have been a number of significant pandemics in human history, generally zoonoses that stemmed from the domestication of animals, such as influenza and tuberculosis. The following table is a list of epidemics that have occurred in North America.

Significant Epidemics in North America (Source: Wikipedia, Coenraads 2006:428-429)

Year	Epidemic	Location	Year	Epidemic	Location
1518-1600	Smallpox	Indigenous societies	**1820-1823**	Fever	United States
1657, 1687	Measles	Boston, Massachusetts	**1831-1834**	Cholera	United States
1690	Yellow fever	New York, New York	**1837**	Typhus	Philadelphia, Pennsylvania
1713, 1729	Measles	Boston, Massachusetts	**1841**	Yellow fever	United States (especially severe in the south)
1738	Smallpox	South Carolina	**1847**	Yellow fever	New Orleans
1739-1740	Measles	Boston, Massachusetts	**1848-1849**	Cholera	North America
1747	Measles	CT, NY,PA, SC	**1850**	Yellow fever	United States
1759	Unknown type	North America	**1850-1851**	Influenza	North America
1761	Influenza	North America and West Indies	**1851**	Cholera	Illinois, Missouri, and the Great Plains
1772	Measles	North America	**1852, 1855**	Yellow fever	United States
1775	Smallpox	North America, esp. Northeast	**1860-1861**	Smallpox	Pennsylvania
1783	Bilious disorder	Dover, Delaware	**1865-1873**	Smallpox	Philidelphia, NYC, Boston, New Orleans
1788	Measles	Pennsylvania and New York	**1865-1873**	Cholera	Baltimore, Memphis, Washington, DC
1793	Influenza and "putrid fever"	Vermont	**1865-1873**	Typhus, typhoid, scarlet & yellow fever	United States
1793	Influenza	Virginia	**1873-1875**	Influenza	North America and Europe
1793-4, 96-97	Yellow fever	Philadelphia , Pennsylvania	**1949, 1952**	Polio	United States
1793	Unknown types	Pennsylvania	**1980-present**	AIDS	Worldwide
1803	Yellow fever	New York	**2009**	H1N1 Influenza	Mexico, United States, Canada

The following table lists some pandemics that have occurred throughout the history of the world.

Significant World Pandemics

Source: Adapted from Wikipedia online encyclopedia

Year	Pandemic	Description
165-180, 251-266	Antonine Plague	The Antonine Plague may possibly have been smallpox brought back from the Near East. It killed a quarter of those infected and up to five million in all. At the height of a second outbreak (251-266) 5,000 people a day were said to be dying in Rome.
541	Plague of Justinian	The Plague of Justinian was the first recorded outbreak of the bubonic plague. It started in Egypt and reached Constantinople the following spring, killing (according to the Byzantine chronicler Procopius) 10,000 a day at its height and perhaps 40 percent of the city's inhabitants. It went on to destroy up to a quarter of the human population of the eastern Mediterranean.
1346-1352, 1665-1666	Bubonic Plague (“Black Death”)	Eight hundred years after its last outbreak, the bubonic plague returned to Europe. Starting in Asia, the disease reached Mediterranean and western Europe in 1348 and killed twenty million Europeans in six years, a quarter of the total population (and up to half the population in the worst-affected urban areas). The 17th Century plague strongly affected England and may have killed 100,000 persons.
1816 - 1826 1829 – 1851 1852 – 1860 1963 – 1875 1899 – 1923 1961 - 1966	Cholera	The first pandemic (1816-1826). Previously restricted to the Indian subcontinent, the pandemic began in Bengal, then spread across India by 1820. It extended as far as China and the Caspian Sea before receding. The second pandemic (1829-1851) reached Europe, London in 1832, Ontario and New York in the same year, and the Pacific coast of North America by 1834. The third pandemic (1852-1860) mainly affected Russia, with over a million deaths. The fourth pandemic (1863-1875) spread mostly in Europe and Africa. The fifth pandemic (1899-1923) had little effect in Europe because of advances in public health, but Russia was badly affected again. The sixth pandemic began in Indonesia in 1961, called El Tor after the strain, and reached Bangladesh in 1963, India in 1964, and the USSR in 1966.
1918 - 1919	Spanish Flu	The Spanish Flu began in August 1918 in three disparate locations: Brest, France; Boston, Massachusetts; and Freetown, Sierra Leone. An unusually severe and deadly strain of influenza spread worldwide. The disease spread across the world, killing 25 million in the course of six months; some estimates put the total of those killed worldwide at over twice that number. An estimated 17 million died in India, 500,000+ in the United States and 200,000 in the UK. It vanished within 18 months.
1957-1958	Asian Flu	Influenza A (H2N2) caused about 70,000 deaths in the United States. First identified in China in late February, 1957, the Asian flu spread to the United States by June 1957.
1959-Present	AIDS	The World Health Organization estimates that millions now die from AIDS each year, worldwide.
1960s	Cholera	El Tor was identified again in an outbreak in 1937 but the pandemic did not arise until 1961 in Sulawesi. El Tor spread through Asia (Bangladesh in 1963, India in 1964) and then into the Middle East, Africa, and Europe. From North Africa it spread into Italy by 1973. In the late 1970s there were small outbreaks in Japan and in the South Pacific.
1968-1969	Hong Kong Flu	Influenza A (H3N2) caused about 34,000 deaths in the United States. This virus was first detected in Hong Kong in early 1968 and spread to the United States later that year. Influenza A (H3N2) viruses still circulate today.
2002-2003	SARS	After the People's Republic of China suppressed news of the outbreak both internally and abroad, the disease spread rapidly, reaching neighboring Vietnam in late February 2003, and then other countries via international travelers. The last case in this outbreak occurred in June 2003. There were a total of 8,069 cases of disease and 775 deaths.

Programs and Initiatives

Michigan Department of Community Health

The Michigan Department of Community Health and local and district health departments across the state have a number of programs and initiatives in place to protect the health, safety and well being of Michigan’s residents. These programs and initiatives have been very successful in preventing, or limiting the scope and magnitude of, the types of public health emergencies described above. However, because the types of threats to public health are always changing, and because the population is becoming larger and more mobile, the possibility always exists for a local, regional, or statewide public health emergency to occur.

The Director of the Department of Community Health, and local public health officers, have the authority (under the Michigan Public Health Code—1978 PA 368, as amended) to take those steps determined necessary and prudent to prevent epidemics and the spread of hazardous communicable diseases, or to effectively mitigate other conditions or practices that constitute a menace to public health. The Director and local public health officers can issue written orders to implement the required preventive steps and/or responses, and those orders can be enforced

through the imposition of civil and criminal penalties for failure to comply. State and local health departments have detailed, written emergency operations plans that address public health emergencies.

The World Health Organization

The World Health Organization (WHO) has established six levels of pandemic "phases," based upon observable phenomena, and allowing the easy incorporation of new recommendations and approaches into existing national preparedness and response plans. Phases 1 to 3 concern preparedness activities, including capacity development and response planning, while Phases 4 to 6 indicate a need for response and mitigation efforts. After a first pandemic wave has occurred, particular "periods" are defined, to facilitate post pandemic recovery activities.

Inter-Pandemic Period (phases 1 and 2):

Phase 1: No new influenza virus subtypes have been detected in humans. An influenza virus subtype that has caused human infection may be present in animals. Although present in animals, the risk of human disease is considered to be low.

Phase 2: No new influenza virus subtypes have been detected in humans. However, a circulating animal influenza virus subtype poses a substantial risk of human disease.

Pandemic Alert Period (phase 3, 4, and 5):

Phase 3: Human infection(s) with a new subtype has caused sporadic cases or small clusters of disease in people, but has not resulted in human-to-human transmission sufficient to sustain community-level outbreaks. Limited human-to-human transmission may occur under some circumstances, or may affect close contacts.

Phase 4: Small clusters include limited human-to-human transmission, but the spread is highly localized, suggesting that the virus is not well adapted to humans. The ability to cause sustained disease outbreaks in a community marks a significant upward shift in the risk for a pandemic. Phase 4 indicates a significant increase in the risk of a pandemic but does not necessarily mean that a pandemic is a forgone conclusion.

Phase 5: Large outbreak clusters occur, but human-to-human spread is still localized, suggesting that the virus is becoming better adapted to humans, but may not yet be fully transmissible. (substantial pandemic risk)

Pandemic Period (phase 6):

Phase 6: Pandemic phase, with increased and sustained transmission in the general population.

During the post-peak period, pandemic disease levels in most countries with adequate surveillance will have dropped below peak observed levels. The post-peak period signifies that pandemic activity appears to be decreasing. However, it is uncertain whether additional waves will occur, and countries therefore need to be prepared for a second wave. Previous pandemics have been characterized by waves of activity spread over months. Once the level of disease activity drops, a critical communications task will be to balance this information with the possibility of another wave. Pandemic waves can be separated by months, and an immediate "at-ease" signal may be premature. In the post-pandemic period, influenza disease activity will have returned to levels normally seen for seasonal influenza. It is expected that the pandemic virus will behave as a seasonal influenza A virus. At this stage, it is important to maintain surveillance, and to update pandemic preparedness and response plans accordingly. An intensive phase of recovery and evaluation may be required.

U.S. Centers for Disease Control and Prevention

At the national level, the U.S. Centers for Disease Control and Prevention (CDC), a branch of the Department of Health and Human Services, has the responsibility and authority to investigate public health emergencies to determine their cause, probable extent of impact, and appropriate mitigation measures. The CDC can also assist state and local public health officials in establishing health surveillance and monitoring systems/programs, and in disseminating information on prevention and treatment to the general public. The CDC announced dedicated funding for bioterrorism response, and Michigan has been strengthening its surveillance and intervention infrastructures with these funds. Since 2001, the CDC has also provided dedicated funding for public health emergency preparedness programs. In 2002, the MDCH Office of Public Health Preparedness was established to oversee these cooperative agreements. In the 2009 Influenza A (H1N1) event, CDC coordinated with numerous

health departments across the country, tracked influenza cases, and provided information about outbreak trends. Tests were also performed, to verify whether flu cases were indeed of the correct type.

Disease Information Website

The State of Michigan maintains a website titled "Emerging Disease Issues" at www.michigan.gov/emergingdiseases that provides a wealth of information on infectious diseases that may be transmitted among humans or between animals and humans. The website features information provided by several Michigan state agencies (e.g., Community Health, Agriculture and Rural Development, and Natural Resources), state universities, federal agencies, local health departments, and various national and international health organizations and professional disciplines. At the time of this writing, the website addressed the following diseases in depth: Bovine Tuberculosis, West Nile Virus, Chronic Wasting Disease, Rabies, Lyme Disease, Avian Influenza, Foodborne Illness, and a wide array of U.S. and foreign animal diseases. The Department of Community Health also maintains a website for chemical-related public health issues at
http:www.michigan.gov/mdch/0,1607,7-132-2945_5105---,00.html
It includes data and links to other websites regarding the human health effects of many hazardous substances, including dioxin, heavy metals, pesticides and others.

Michigan Pandemic Influenza Plan

In October 2009, the Michigan Department of Community Health updated the "Michigan Pandemic Influenza Plan," to provide response guidelines for an influenza pandemic affecting Michigan. Although the plan cannot eliminate the disease, it will aid in reducing the impact by enabling state and local agencies to anticipate, prepare for, and respond efficiently and effectively to the disease. The plan, which is divided into pre-pandemic, pandemic, and post-pandemic phases, details necessary activities at the state and local level related to:

- command and management,
- crisis communications,
- surveillance,
- laboratory testing,
- community containment,
- infection control in health care facilities,
- vaccines and antivirals/medical management,
- data management,
- border/travel issues
- recovery

The Michigan Pandemic Influenza Plan is available for review and downloading at www.michigan.gov/flu.

U.S. Health and Human Services Pandemic Influenza Plan

Like the State of Michigan, the federal government also has developed a plan to address the threat of pandemic influenza. The "HHS Pandemic Influenza Plan," released in November 2005 and updated three times in 2006, is the federal government's blueprint for pandemic influenza preparation and response. It provides guidance to national, state, and local policy makers and health departments, to aid all involved in achieving a state of readiness and quick response. The HHS Pandemic Influenza Plan includes an overview of the threat of pandemic influenza, a description of the plan's relationship to other federal plans, and an outline of the key roles and responsibilities during a pandemic. The plan is available for review and downloading at www.hhs.gov/pandemicflu/plan/.

Michigan Health Alert Network

The "Michigan Health Alert Network" (MIHAN) is a secure, statewide web-based disease alert system serving over 4,000 health care providers and other critical responders at local health departments, hospitals, clinics, and several state governmental agencies. The Michigan Department of Community Health (MDCH) has implemented the MIHAN to enhance the State's emergency public health communications system and serve as a platform for health alerts, prevention guidelines, national disease surveillance, and electronic laboratory reporting. It is used

by the MDCH Office of Public Health Preparedness to support and strengthen preparedness and response for bio-terrorism, public health, and medical emergencies, at the local, state, and federal levels. The MIHAN provides role-based alerting and permissions, secure web-based communication, and bi-directional alerting with message confirmation by telephone, e-mail, and text pager, plus broadcast facsimile capabilities. The MIHAN serves as a foundation for the integration of public health and emergency response partners throughout Michigan, plus tribal health centers, border states, Canada, and federal agencies, including the U.S. Centers for Disease Control and Prevention (CDC).

Food Law (2000 PA 92)

The Food Law of 2000 was enacted to modernize, standardize, and consolidate Michigan's food laws, while adopting the U.S. Food and Drug Administration's (FDA) 1999 Food Code as a uniform regulatory standard for retail food establishments such as restaurants, other food service facilities, groceries, and convenience stores. The law helps to protect Michigan consumers from serious foodborne illnesses such as E. coli, salmonella, listeriosis, botulism, and hepatitis.

U.S. Food and Drug Administration Food Code

The U.S. Food and Drug Administration (FDA) Food Code is the national regulatory standard for retail food establishments. The FDA Food Code is neither Federal law nor Federal regulation, but represents the FDA's best advice for a uniform system of regulation to ensure that food at retail establishments is safe and properly protected and presented. It may be adopted and used by agencies at all levels of government that have responsibility for managing food safety risks at the retail level. The Food Code provides practical, science-based advice and manageable provisions for mitigating risk factors known to contribute to foodborne illnesses. Michigan initially adopted the 1999 FDA Food Code with the Michigan Unified Food Law of 2000 (2000 PA 92). The FDA Food Code is revised every two years.

(Note: For information on specific programs and initiatives aimed at mitigating water and sewer system failures, please refer to the Infrastructure Failures section.)

Hazard Mitigation Alternatives for Public Health Emergencies

- Immunization programs to vaccinate against communicable diseases.
- Improving ventilation techniques in areas, facilities, or vehicles that are prone to crowding, or that may involve exposure to contagion or noxious atmospheres.
- Radon detection and abatement activities, to reduce concentrations of radon in homes and buildings.
- Maintaining community water and sewer infrastructure at acceptable operating standards.
- Providing back-up generators for water and wastewater treatment facilities to maintain acceptable operating levels during power failures.
- Demolition and clearance of vacant condemned structures to prevent rodent infestations.
- Free or reduced-expense community clinics and school health services.
- Brownfield and urban blight clean-up activities.
- Proper location, installation, cleaning, monitoring, and maintenance of septic tanks.
- Separation of storm and sanitary sewer systems.

Tie-in with Local Hazard Mitigation Planning

Because many means of implementing mitigation actions occur through local activities, this updated MHMP places additional emphasis on the coordination of State-level planning and initiatives with those taking place at the local level. This takes two forms:

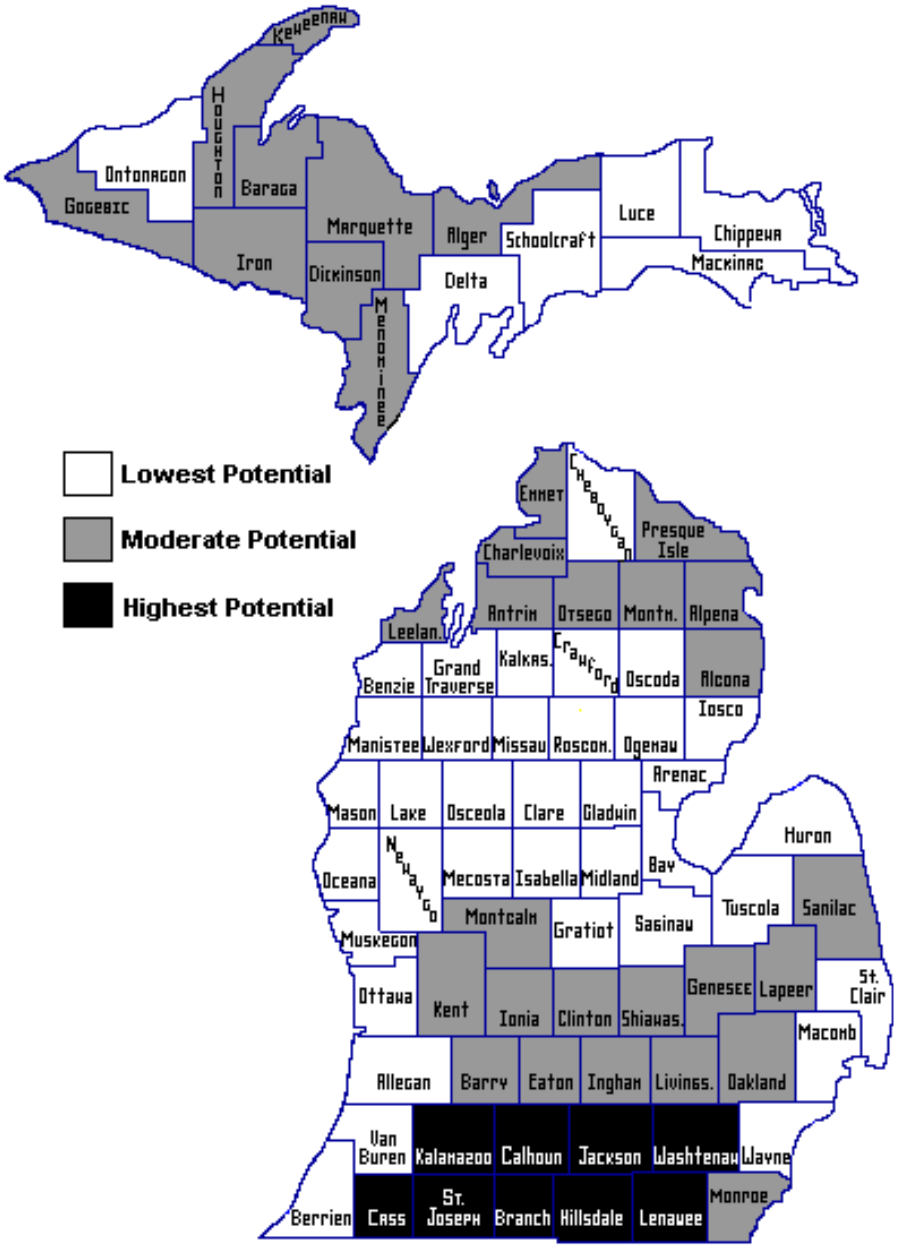
1. The provision of guidance, encouragement, and incentives to local governments by the State, to promote local plan development (including a consideration of drought conditions), and

2. The consideration of information contained in local hazard mitigation plans when developing State plans and mitigation priorities.

Regarding the first type of State-local planning coordination, MSP guidance has included the "Local Hazard Mitigation Planning Workbook" (EMD-PUB 207), which is currently being updated for release by 2015. For the second type of State-local planning coordination, a section later in this plan summarizes hazard priority information as it has been reported in local hazard mitigation plans. Here, it will merely be noted that public health emergencies were identified as one of the most significant hazards in local hazard mitigation plans for the following counties: Huron, Jackson, Marquette, Midland, and Saginaw.

Radon Zones in Michigan

This map was developed by the U.S. Environmental Protection Agency (EPA) using five factors to determine radon potential: indoor radon measurements, geology, aerial radioactivity, soil permeability, and foundation type.



Source: Adapted from an Environmental Protection Agency map

(Note: Consult the EPA Map of Radon Zones document (EPA-402-R-93-071) for additional background information on this map. That document also contains information on radon potential variation <u>within</u> counties. The EPA also recommends that this map be supplemented with any available local data in order to further understand and predict the radon potential of a specific area.)

TERRORISM AND SIMILAR CRIMINAL ACTIVITIES

Terrorism: "…activities that involve violent…or life-threatening acts…that are a violation of the criminal laws of the United States or of any State and…appear to be intended (i) to intimidate or coerce a civilian population; (ii) to influence the policy of a government by intimidation or coercion; or (iii) to affect the conduct of a government by mass destruction, assassination, or kidnapping" Federal criminal code. 18 U.S.C. §2331

Hazard Description

Terrorism is the use of violence by individuals or groups to achieve political goals by creating fear. The political motives of terrorism distinguish it from ordinary crime. Terrorism is carried out for a cause; not for financial gain, personal revenge, or a desire for fame.

Terrorism is a long-established strategy that is practiced by many groups in many nations. The United States is threatened not only by international terrorists such as Al Qaeda, but also by home-grown domestic terrorist groups including racist, ecological, anti-abortion, and anti-government terrorists.

A wide range of techniques can be used by terrorists, including bombings, shootings, arson, and hijacking. Regardless of the specific tactics used, terrorists seek the greatest possible media exposure. The goal of terrorists is to frighten as many people as possible, not necessarily to cause the greatest damage possible. Media coverage allows terrorists to affect a much larger population than those who are directly attacked.

Non-terrorist criminal activity may resemble terrorism, but lacks a political objective. Emergency management is typically not concerned with routine, individual crimes, but does need to prepare for crimes that impact large portions of the population. Such attacks may require resources not available to local law enforcement agencies. Crimes of this sort include mass shootings, random sniper attacks, sabotage of infrastructure, and cyber-attacks. The types of criminal attacks considered in this section are those that resemble terrorism or that may cause widespread immediate disruption to society.

Hazard Analysis

Terrorism in the United States

Terrorists intend to use fear as a weapon to achieve their goals. This approach allows a small, weak group to potentially influence the actions of an entire nation or government. Terrorists lack the power to achieve their ultimate aims through the direct use of force, but by staging relatively small attacks in a spectacular fashion, they hope to have a major political impact. Their goals are effectively summarized by the proverb "Kill one, frighten 10,000." Terrorism can be an effective strategy for a weak group to use when fighting a strong opponent.

Terrorism has been used for thousands of years, but modern terrorism developed in the 19th Century. The United States has suffered from terrorist attacks for more than a century: U.S. President William McKinley was assassinated by an anarchist terrorist in 1901, the Los Angeles Times building was destroyed in 1910, and Wall Street was bombed in 1920. Racial and religiously-motivated terrorism continued throughout the 20th century. A new wave of terrorism was instigated in the 1960s by left-wing radicals. This was followed by right-wing extremist terrorism in the 1980s and 1990s. All of these attacks were conducted by American domestic terrorists against other Americans.

The United States has also been the target of terrorists from other countries. Conflict in the Middle East led to many attacks on American targets overseas, primarily by Palestinian nationalist terrorists, as well as groups supported by Libya and Iran. Hijackings, kidnappings, and bombings of Americans occurred throughout the 1970s and 1980s, and into the 1990s. By the mid-Nineties the danger had shifted toward attacks by violent Islamic extremist groups such as al-Qaeda. Al-Qaeda successfully moved their terrorist campaign inside of the United States homeland with the World Trade Center bombing in 1993 and the devastating 9/11 attacks in 2001.

Types of Terrorists

Terrorists fall into five major categories, based upon the political cause that motivates their actions. These categories are: nationalist, religious extremists, left wing terrorists, right wing terrorists, and single-issue terrorists.

Nationalist terrorists act in support of a cultural or ethnic group. Typically they are fighting on behalf of national populations that wish to have an independent government, but are currently ruled by another country. Nationalist terrorists tend to direct their attacks against the "occupying power" that they wish to drive away, but may also attack other nations that support their enemies. Nationalist terrorists claim to speak for their entire national group, but usually only represent a small minority of extremists. Examples of nationalist terror groups include the Provisional Irish Republican Army (Northern Ireland), the Popular Front for the Liberation of Palestine (Palestine), and the Armed Forces of National Liberation (Puerto Rico).

Religious extremist terrorists are violent adherents of a specific religion. They may be violent extremists within a large, generally peaceful faith such as Islam or Christianity, or members of a small "cult" religion in which the entire group is extremist. These terrorists tend to be especially committed because they believe their violent actions are supported by their deity and because they may expect to be rewarded after death. Religious terrorists see themselves as fighting in a battle of ultimate good against pure evil, in which any action is justified. Examples of religious extremist terrorists include al Qaeda (International), Hezbollah (Lebanon), and the Aum Shinrikyo cult (Japan).

Left wing terrorists attempt to force society to change to match their goals and values. They tend to target the government, powerful institutions, and symbols of authority. Socialist and Communist terrorists of this type were a threat in the late 1960s and 1970s, but have weakened in recent decades. Examples of left-wing terrorist groups include the Weathermen (United States), the Red Army Faction (Western Europe), and Shining Path (Peru).

Right wing terrorists see themselves as fighting for traditional values against an invading group and/or against a tyrannical government. In the United States these terrorists are associated with anti-immigration, white supremacy, anti-government, and Christian Identity movements. Only the most extreme elements of these movements have become terrorists, but they have carried out a substantial portion of the recent attacks in the United States. Right wing groups tend to target members of hated ethnic or religious minorities, or government employees. In recent years, right wing terrorists have usually operated as violent individuals termed "lone wolves" and not in organized groups. Examples of right wing terrorist groups in the United States include "The Covenant, The Sword, and the Arm of the Lord" and "The Order." Examples of right-wing "lone wolf" terrorists include Timothy McVeigh (of the 1995 Oklahoma City bombing) and James von Brunn (of the 2009 National Holocaust Museum shooting in Washington, D.C.).

Single-issue terrorists are not committed to an all-encompassing belief system, but rather are intensely concerned with one particular cause. Frequently these issues are of interest to many members of society, but only small numbers of individuals convert this interest into terrorist action. Common causes for single issue terrorists in the United States include animal-rights, environmentalism, and opposition to abortion. These terrorists carry out the majority of terrorist attacks within the United States, but tend to target property or individuals rather than attempting to cause massive casualties. Examples of American single issue terrorist groups include the Animal Liberation Front and the Earth Liberation Front, but many single issue terrorists operate as independent lone wolves or in small informal groups.

Terrorists and terrorist groups tend to fall into one of these five categories, but there are examples of terrorists who fit more than one of these categories. For example, nationalist terror groups have often promoted radical left-wing political views while religious extremist terrorists frequently have extreme right-wing views.

The most effective terrorists tend to operate in groups of like-minded individuals. Such groups range from a few committed amateurs to sophisticated international paramilitary organizations. Even in the larger organizations, terrorist groups are structured into small "cells" with a handful of members each. This structure, combined with the intense personal commitment of many terrorists, makes these groups difficult to discover, infiltrate, and disrupt.

Non-terrorist Criminals

Terrorism is a crime, but not all criminals are terrorists. Most crimes impact only a small number of victims and are appropriately handled by local law enforcement. Rarely, a criminal event will impact a large number of people. Examples include mass-shootings at schools or workplaces, infrastructure sabotage, and cyber-attacks. Such major criminal events may resemble terrorist attacks, but there are important differences between terrorists and other criminals.

The principal difference between terrorism and other types of crime is motivation. Terrorists are motivated by a political cause, not by personal gain. Terrorism is not only defined by what an attacker does, but why he or she does it. This is an important distinction because it explains other characteristic differences between terrorism and non-terrorist crimes.

Non-terrorist criminals may be driven by a wide variety of purposes. These motivations are highly idiosyncratic and difficult to categorize or predict. Most criminals avoid major crimes with widespread impact because the chance of monetary gain is low and the risk of punishment is high. Occasionally a criminal will be willing to take that risk. Major criminal events have been conducted for reasons of personal revenge, monetary gain, desire for fame, and due to mental illness.

There are other important differences between terrorists and criminals, although these are generalizations that do not hold true in all cases. Terrorists tend to prioritize their mission over their personal safety and will often risk capture or death to achieve their goals. Criminals usually seek freedom to enjoy the rewards of their crimes and so plan to escape undetected after their attacks. American criminals, especially those who conduct large-scale attacks, tend to operate as individuals or small groups. The most effective terrorists belong to organizations or networks that coordinate multiple members and share extensive resources.

Criminal and Terrorist Weapons and Techniques

There are a wide variety of harmful weapons and tactics available to terrorists and criminals. The specific effects of a terrorist or criminal attack, as well as the emergency response required, are determined largely by the tools used.

Explosives are by far the most common terrorist tool and have also been used by particularly violent criminals. Bombs have many advantages for an attacker, including flexibility, availability, and ease of use. Explosives can be delivered in many ways, including massive car bombs, hidden suicide vests, assassination devices, and letter bombs sent through the mail. Bombs are effective at both destroying property and harming people. Explosive attacks also produce dramatic images of destruction guaranteed to receive the media coverage that terrorists seek out.

A wide variety of explosive materials are available. Military explosives are the most powerful, but are difficult for most terrorists and criminals to get. Commercial explosives are widely available for legitimate use by mines, farms, and businesses. With over 2.5 million tons used each year in the United States, commercial explosives are powerful and easy to acquire. Alternatively, terrorists and criminals may choose to make their own explosives. Effective bombs can be built from commonly available materials such as farm fertilizer, diesel fuel, and hydrogen peroxide.

Explosives are also relatively easy to use. This allows even untrained bombers to launch damaging attacks. Common terrorist tactics include anti-personnel bombs, packed with metal objects to increase injuries, and suicide bombs that can be set off at the most harmful possible time and place. For non-suicidal attackers, bombs can be left in place to explode long after the bomber has made an escape. One common explosives technique of particular importance to emergency responders is the secondary device. This tactic uses a pair of bombs, the first of which draws rescuers and bystanders to the scene and a second, hidden bomb is targeted to then kill these emergency responders.

Explosive attacks can be countered by careful law enforcement work to identify and disrupt possible attacks before they occur. Alert and properly educated citizens can provide important assistance by observing and reporting signs of a possible attack, such as an unwarranted purchase of explosive materials, or the presence of a suspicious package in a public place. Some high-risk areas such as airports can be equipped with explosives screening devices. Particularly high-risk facilities, such as government buildings, may be physically hardened to limit the damage from attack by explosives. If a bomb or potential bomb is detected, specially trained law enforcement bomb squads should be contacted to dispose of it.

Case: Bath School Disaster (1927)
On May 18, 1927, the Bath Consolidated School in Bath, Michigan, was the target of an attack with explosives. The bomber was probably motivated by personal revenge against the local school district (stemming from a taxation issue), and so this event is classified as criminal, rather than as a terrorist attack. Although many of the explosives failed to detonate, the bombs in the school killed dozens of students and teachers. The bomber also destroyed his home and farm with explosives. Immediately after the school attack, the bomber approached the rescue operations scene and detonated an explosive device carried in his vehicle, killing himself, local officials, and several bystanders. The final death toll was 45, with 58 additional persons injured. The Bath Disaster remains the second most deadly U.S. bombing attack, after the Oklahoma City Bombing, as well as the most lethal attack on an American school. This case also provides early examples of such tactics now in common use by terrorists, including a secondary device, suicide bombing, and car bomb.

Case: Oklahoma City Federal Building Bombing (1995)
On April 19, 1995, the Alfred P. Murrah Federal Building in Oklahoma City, Oklahoma, was attacked by a large truck bomb. The attack killed 168, injured more than 680, destroyed the building, and caused widespread destruction over a sixteen-block area. Although initially suspected of being carried out by international terrorists, the attackers were in fact anti-government domestic terrorists, one of whom had extensive Michigan connections. This attack is an example of right wing anti-government terrorism. It also demonstrates the extensive destruction that can be caused to large buildings which lack adequate target hardening and security measures.

Case: Bali Bombing (2005)
On October 12, 2002 terrorists bombed the tourist district of Kuta on the Indonesian Island of Bali. The targets were several nightclubs frequented by Western tourists. An initial backpack suicide bomb was directed against patrons inside a dance club. Shortly thereafter, a large car bomb detonated on a busy street near the first attack, killing survivors of the initial bomb and would-be rescuers. The second bomb weighed over a ton and devastated several blocks of buildings. In total, 202 persons were killed, with a further 209 injured. The attack was carried out by Jemaah Islamiyah, an Indonesian extremist Islamist organization. This case is an example of the versatility of terrorist explosives, used at Bali as both a small suicide weapon and a massive remotely detonated car bomb. It is also an example of a large secondary device, intended to kill those responding to the initial bomb.

Case: Northwest Airlines Flight 253 Bombing Attempt (2009)
On Christmas Day 2009, Umar Farouk Abdulmutallab attempted to destroy Northwest Airlines Flight 253, approaching Detroit Metropolitan Airport. The weapon used was an explosive device provided by the “al-Qaeda in the Arabian Peninsula” terrorist group and hidden in his underwear. The device was small and easy to conceal, but was capable of damaging or destroying the airliner. The explosive failed to detonate properly and instead

ignited and burned Mr. Abdulmutallab, who was then subdued by the plane's passengers and crew. This attack demonstrates the potential effectiveness of even small bombs when used against vulnerable targets such as aircraft. It also demonstrates that international terrorism may be directed at targets in Michigan.

Case: Boston Marathon Bombings (2013)
On April 15, 2013, the finish line of the Boston Marathon was targeted by two improvised explosive devices. Three persons were killed and up to 260 others injured, including many with amputated limbs. The two men who delivered the bombs were quickly spotted on security camera video and were soon identified as brothers Dzhokhar and Tamerlan Tsarnaev. An extensive manhunt resulted in the closure of a portion of downtown Boston, a temporary halt to air travel, a shelter-in-place advisory, and extensive armed searches of residential neighborhoods. The Tsarnaev bothers committed several additional crimes during their flight, including the murder of a police officer, before Tamerlan was killed and Dzhokhar captured by law enforcement. The Boston Marathon Bombing appears to have been a terrorist attack motivated by Islamic religious extremism, though the brothers had very limited direct contact with international Islamic terrorist groups. Dzhokhar Tsarnaev is now facing numerous federal terrorism charges. This case is an example of the large number of casualties which can be inflicted by even primitive explosives in crowded public areas. It also demonstrates that effective bomb attacks can be carried out by individuals without extensive training or support from established terrorist groups. Finally, this case illustrates the widespread social disruption caused both by fear of terrorists on the loose and by aggressive law enforcement pursuit of those terrorists.

Suggested cases for readers' further study: (1) 1993 World Trade Center bombing (demonstrates the importance of terrorist planning), (2) 2005 London transit bombing (demonstrates the use of small improvised devices), (3) 1955 Flight 629 insurance bombing (demonstrates a criminal attack against an airliner; related cases include Flight 967 of 1959, Flight 2511 of 1960, and Flight 11 of 1962), (4) 2004 Madrid train bombings (demonstrates political benefits for terrorists).

Incendiaries are similar to explosives and share many characteristics. Incendiaries are used to start fires rather than to destroy through explosion. Generally they are targeted at structures and property rather than directly against people. This makes incendiaries appealing to groups such as animal rights terrorists that seek to minimize casualties. The devices can be as simple as a can of gasoline ignited on a porch, or as sophisticated as a military thermite bomb. The use of fuel-laden jetliners as suicide missiles in the 9/11 attacks can be considered a massive application of improvised incendiary devices.

Countermeasures against incendiary attack are very similar to those against explosive attacks. Effective law enforcement, good intelligence on potential attackers, surveillance of critical sites, and hardening of particularly vulnerable targets can all be helpful. Note that the construction of simple incendiary devices can be very difficult to prevent since there are no legal restrictions on incendiary materials such as gasoline and matches. Prompt fire detection and effective firefighting can limit the damage once an attack occurs.

Case: Michigan State University Agriculture Building Arson (1999)
On December 31, 1999, environmental terrorists affiliated with the Earth Liberation Front (ELF) set fire to the Agriculture Biotechnology Support Project, located in a classroom and office building at Michigan State University. The university was targeted because of its work on genetically modified crops. The fire was set when there were few people in the building. Damages to the building and research equipment totaled approximately $1 million. Four domestic terrorists from Michigan and Ohio were later tried and convicted in federal court for carrying out this attack. This attack, a similar attack against Michigan State in 1992, and an attempted attack against the Michigan Technological University Forestry Center in 2001 are all typical of attacks by environmental terrorist groups. These attacks generally are designed to cause property damage but few deaths and injuries. These attacks also demonstrate the vulnerability of universities and research centers to terrorist attack.

Case: 9/11 Airliner Attacks (2001)
On the morning of September 11, 2001, terrorists hijacked four commercial airliners originating from Boston Logan Airport, Newark International Airport, and Washington Dulles International Airport and then deliberately crashed the aircraft into the World Trade Center in New York City, and the Pentagon in Arlington, Virginia (with a fourth crashing in rural Pennsylvania), killing approximately 3,000 persons and causing billions of dollars in property damage. This coordinated attack was the deadliest act of terrorism in history. The attack would have been even worse had the fourth aircraft hit its intended target, which was presumed to be the White House in Washington, D.C. Instead, passengers attacked the hijackers, probably causing them to crash the aircraft into the open field in Pennsylvania.

Although these attacks began as hijackings, they may be classified as incendiary terrorism because most of the damage was caused by large fires started by the crashing airliners and their spilled jet fuel. It was these fires that caused the collapse of the three largest buildings at New York's World Trade Center, and of portions of the Pentagon building.

These attacks caused major disruption to airline travel, including a temporary ban on all civilian flights in the United States. Significant and expensive changes were made to improve security at airports and aboard aircraft. Substantial damage was caused to the overall U.S. economy, due to the direct and indirect costs of the attacks. With the 9/11 attacks as justification, the United States and its allies launched major military campaigns in Afghanistan, Iraq, and Pakistan that have cost tens of thousands of lives and trillions of dollars. This one terrorist operation, conducted by 19 men armed with knives, continues to have global repercussions years after the event.

The 9/11 attacks demonstrate the ability of terrorists to seek out vulnerabilities and to creatively exploit them. The attacks were incredibly effective because the terrorist tactics were unexpected, and terrorists will continue to attempt to surprise their targets with new weapons and techniques. These attacks also illustrate that a major terrorist attack can have repercussions that extend well beyond the immediate scene of the attack.

Suggested case for readers' further study: 1974 "Alphabet Bomber" Muharem Kurbegovich (example of multiple incendiary attacks as part of an individual's terror campaign).

Shooting attacks are a popular tactic for both terrorists and criminals. Firearms can be used to target a specific individual or to attack many people in a crowded place. Small arms such as pistols, rifles, and shotguns are easily available in the United States, including semi-automatic weapons with large capacity magazines. Shootings at schools and workplaces are among the most common types of major criminal attack.

An important drawback to the use of firearms, particularly in a mass shooting, is that the attacker is not likely to escape. Therefore shootings are usually carried out by suicide attackers, those expecting to be arrested, or criminals who are acting impulsively and without thought to consequences.

Countermeasures against shooting attacks are difficult, since attackers usually choose unprotected public areas. Protection against attacks has to be balanced against the public's need to use their schools, shopping malls, government buildings, and workplaces. Appropriate security measures and effective lock-down training can limit casualties in high-risk buildings such as schools. Rapid response by well-trained law enforcement officers and emergency medical personnel is also very important.

Case: Columbine School Shooting (1999)
On April 20, 1999, two students staged an attack at Columbine High School near Denver, Colorado. Although the criminals attempted to use explosives, all of the casualties were inflicted with small arms. Using a variety of handguns and shotguns, the criminals killed 13 teachers and students and wounded 24 others. By targeting crowds of students during lunch, the attackers were able to inflict all of the casualties within 23 minutes. The criminals expected to die during the attack and took their own lives at the end of their assault. This attack demonstrates the

vulnerability of facilities, such as schools, where large numbers of victims can be founds in close proximity. It also illustrates the short duration of most mass shooting attacks and the need for a very rapid law enforcement response.

Case: Mumbai Attacks (2008)

On November 26, 2008, terrorists attacked the Indian city of Mumbai. The primary weapons employed were rifles and handguns, though small explosives were also used. Ten terrorists attacked six targets across Mumbai's downtown area, including hotels, a railway station, a hospital, a restaurant, and a Jewish community center. There were also shootings on the city streets and several diversionary attacks. In total, more than 160 persons were killed and more than 290 injured. Sixteen of the dead and many of the injured were law enforcement officers. The attack was conducted by Lashkar-e-Taiba, a Pakistani extremist Islamist group. The attackers intended to die during their mission, though one man was taken alive. This case demonstrates the large number of casualties that can be inflicted by firearms in a crowded urban environment. It also demonstrates the significant challenge for law enforcement when suddenly confronted with a number of heavily-armed and suicidal gunmen, and the substantial police casualties which may result.

Case: Fort Hood Shooting (2009)

On November 5, 2009, a single gunman launched a shooting attack at the Fort Hood military post, located near Killeen, Texas. The attacker was Major Nidal Malik Hasan, a U.S. Army psychologist. Using a single handgun, Hasan killed 13 military personnel and wounded 29 others before being subdued. Hasan is accused of terrorism; acting for political reasons related to his extremist Islamist beliefs. It is believed that he was radicalized though the Internet and specifically through contact with Anwar al-Awlaki, a member of the terrorist group "Al Qaeda in the Arabian Peninsula." This case demonstrates the potential lethality of a highly trained and well-equipped gunman. Maj. Hasan made far more effective use of his weapon than other mass shooters, which can be attributed to his high level of training and preparation. It also demonstrates the danger posed by "lone wolf" attackers (self-radicalized and acting outside of the direct control of an established terrorist organization). Finally, it is an alleged example of an American citizen acting on behalf of a cause typically identified with international terrorists. As an American and a member of the military, Maj. Hasan does not fit the expected terrorist profile, which may have enabled him to avoid detection as a deadly threat.

Case: Highway Shootings (2012)

During October 2012, a man shot at cars as they drove along and near a Michigan highway corridor in Oakland, Ingham, Shiawassee, and Livingston counties, over the span of several days. The first car was shot in Commerce Township on October 16th. On that same day, four more shootings occurred in Wixom. On the next day, another Commerce Township shooting took place near the same location as the first day. The northernmost shooting occurred in Perry on October 18th. On that same day, there were eight shootings near the I-96 exit in Webberville. There was also an October 18th shooting in Howell, and six shootings in Wixom. About a week later, on October 27th, two shootings occurred along Grand River and I-96 in the area of Fowlerville, and a driver on I-96 reported being injured by a bullet (the only such instance reported). During his trial, the shooter claimed that shooting at vehicles was connected to a condition of mental illness. Investigators connected him with 24 shooting incidents in the area. In 2014, a Livingston County jury convicted him of terrorism and he was sentenced to 16 to 40 years. This was in addition to a sentence of at least 6 years received in Oakland County. It is possible that additional charges may be sought in Ingham and Shiawassee County. NOTE: Media headlines often simplified these incidents by referring to them as involving "The I-96 Shooter," even though most incidents did not involve Interstate traffic.

Case: Sandy Hook School Shooting

On December 14, 2012, 20-year old Adam Lanza killed his mother in their shared home in Newtown, Connecticut. He then proceeded to Sandy Hook Elementary School where he murdered students and staff members. The attacker entered by shooting through a school window, bypassing the building's locked doors. Using a semi-automatic rifle, he killed twenty children and six adults in less than 10 minutes. Two other adults

were wounded. When police responded, the killer ended the attack by taking own life. No motive has been established for the crimes. This case demonstrates the vulnerability of facilities, such as schools, where large numbers of potential victims can be found in a small area. It also illustrates the short duration of most mass shooting attacks and the need for very rapid law enforcement response. The Sandy Hook Shooting demonstrates the limitations of passive defenses, such as locked doors, when facing an armed attacker. Finally, this case illustrates the willingness of some violent criminals to target even the most innocent and vulnerable victims.

Suggested cases for readers' further study: (1) 2007 Virginia Tech shooting (an example of heavy casualties caused by a single gunman, and of a university target), (2) 2002 Washington D.C. area Beltway Snipers (example of random attacks, the effectiveness of a small team, long-range shooting, and widespread public fear), (3) 2004 Beslan School attack (an example of massive casualties, terrorist targeting of young children, difficult rescue operations, and a large suicide team with military weapons), (4) September 2013 Westgate Shopping Mall attack in Nairobi, Kenya (the shopping mall setting may be relevant to American vulnerabilities).

Chemical weapons attacks involve the use of poisonous materials, usually toxic gases. This is a potentially dangerous type of weapon, but is difficult to use effectively. Poison gas tends to disperse quickly and unpredictably, which reduces casualties even when used on an unsuspecting target. Chemical weapons attacks are very similar in effect to the accidental release of hazardous materials.

As with explosives, there are many possible types of chemical weapons. Military gases such as nerve gases can be deadly, but are difficult to acquire or manufacture. Commercial gases such as chlorine and hydrogen cyanide are produced in massive quantities and easier to find, but they are less effective. One possible terrorist tactic is to attack chemical storage facilities in order to harm the surrounding communities.

Chemical attacks have been rare in practice. Despite their theoretical effectiveness, few terrorists or criminals have attempted to use chemical weapons and most of their attacks have failed.

Case: Tokyo Sarin Attack (1995)
On March 20, 1995, Japanese domestic terrorists launched a poison gas attack on the Tokyo subway system. The perpetrators were members of Aum Shinrikyo, a religious cult with extensive financial and scientific resources. The terrorists manufactured their own supply of the military nerve gas Sarin. This attack demonstrates that while it is difficult to create mass casualties with terrorist chemical weapons, it is comparatively easy to cause mass panic.

Although the nerve gases used in Tokyo were highly lethal, and the attackers intended to cause many casualties, the terrorists had difficulty in spreading the gas effectively. Twelve people died in the attack, approximately fifty were severely injured, and more than a thousand suffered more limited health effects. The attacks did cause considerable alarm, and medical facilities were overwhelmed by uninjured but frightened citizens. One lesson learned from this attack was the importance of preparing first responders and emergency room personnel to deal with chemically contaminated victims.

Suggested case for readers' additional study: Afghan girls' school attacks (an example of non-fatal uses of toxic gas, recent attacks, and schools as targets).

Biological weapons use disease organisms to cause illness and death. This type of attack is sometimes referred to as "germ warfare." Some biological weapon organisms, such as anthrax, will sicken victims that come in contact with weapon materials, but the victims cannot easily spread their disease to others. This type of attack resembles the use of a chemical weapon. Other germ warfare organisms, such as smallpox and plague, can pass from one victim to another, allowing an initially small attack to eventually infect a large number of victims.

Biological weapons may be attractive to terrorists and criminals because some varieties are relatively easy to produce. A widespread disease outbreak could potentially sicken many people and cause widespread panic. In addition, biological terrorism can be targeted against crops or livestock if the attacker wishes to causes significant economic damage instead of human casualties.

Biological weapons also possess drawbacks for potential attackers. The effects are hard to control and a disease released against a terrorist's enemies might very well spread to infect the attacker's friends and allies. Another problem is that the most deadly germ warfare agents, such as smallpox and breathable anthrax, are quite difficult to manufacture. In addition, standard infectious disease control techniques, such as patient isolation, antiseptics, hand washing, and antibiotics, can be very effective countermeasures against biological attacks, just as they are against natural disease outbreaks.

One major consideration for potential biological attacks is that germ warfare is often not recognized as an attack. Victims often do not show symptoms for several days and unlike a bomb explosion or mass-shooting, biological attacks are often mistaken for naturally occurring diseases. This may be an advantage for certain criminals who want their attacks to go unrecognized, but may be a major drawback for a terrorist who wants to use a biological attack to achieve political goals.

Case: Rajneeshee Salmonella Attack (1984)
During September and October 1984, followers of the fringe religious leader Bhagwan Shree Rajneesh deliberately attacked residents of The Dalles, Oregon, with the salmonella organism. Salmonella was spread by means of contaminated glasses of water and by spraying the organism on restaurant salad bars. A total of 751 people were sickened and 45 were hospitalized. None of the victims died.

The attack was an attempt to reduce voter turnout in a local election, allowing the Rajneeshee religious community to gain control of the Wasco County Circuit Court. The perpetrators did not intend for their attack to be recognized. They hoped that it would be mistaken for an accidental outbreak of food poisoning. Only after the group was investigated for other crimes was the outbreak recognized as a deliberate biological attack.

This attack is a creative example of the criminal use of biological agents. It demonstrates the difficulty in identifying a biological event as a deliberate attack.

Case: Amerithrax Anthrax Attack (2001)
In October 2001, several letters contaminated with anthrax were mailed to locations in Florida, New York, and Washington, DC. The intended targets were politicians and members of the media, but most of the victims were accidentally exposed. Twenty-two victims suffered a confirmed anthrax infection and five died. Several structures, including government office buildings and postal facilities, were contaminated by anthrax and required expensive decontamination before they could be reoccupied. Fortunately, anthrax does not spread easily from person to person and the disease outbreak was quickly contained.

The content of the contaminated letters had initially suggested that Islamic terrorists were responsible for the attack. Following shortly after the 9/11 terrorist disaster, the Amerithrax attack was the subject of considerable media coverage and caused great national concern. Public fear was heightened by a large number of "copycat" incidents which followed over the next several months, though fortunately all of these proved to be mere hoaxes.

Eventually federal investigations determined that the attack was conducted by a domestic criminal posing as a foreign terrorist. In 2008, a U.S. government anthrax researcher was identified as the likely source of the attacks. An indictment was sought by the United States Attorney's Office, but the suspect committed suicide before his arrest. The likely motive was personal and professional gain, as the attacks increased funding for the researcher's anthrax vaccine project.

This incident is an example of a criminal use of biological weapons. It demonstrates that it can sometimes be difficult to determine whether an attack is criminal or terrorist in nature. It also shows that attackers are not all foreigners or members of the radical political fringe; in this case the criminal was a highly trusted government employee.

Radiological weapons, sometimes called Radiological Dispersal Devices (RDDs) or "dirty bombs," are weapons designed to spread hazardous radiological materials. These devices do not create a nuclear explosion. The most standard design for a radiological bomb surrounds conventional explosives, such as dynamite or gunpowder, with radioactive materials in the form of powder or scraps of metal. Such a bomb would do the same damage as a normal (non-radiological) explosive and in addition would spread radioactive materials around the area near the explosion.

No radiological weapon has even been used in an actual attack. However, based on U.S. government tests of dirty bomb designs, the health effects of this type of weapon would likely be quite limited. It is difficult to create enough contamination to make victims seriously ill and even more difficult to cause deaths through radiation. It is likely that more people would be killed by the normal explosives in a dirty bomb than would be seriously hurt by the effects of radiation. However, cleaning up an area once it has been contaminated by radioactive materials would be extremely difficult and expensive. In addition, radioactive threats tend to cause a great deal of fear in the general public. This makes radiological weapons potentially very useful for terrorists: they create little actual destruction, but considerable terror and disruption.

Radiological weapons are considered a serious threat because the components for a dirty bomb have legitimate civilian uses and can easily be stolen by terrorists or criminals. Hospitals, food processing plants, and research centers all possess radioactive materials that would be of use in making a weapon. There is a proven black market in radioactive materials, particularly involving sources stolen from Eastern European countries. Plans for radiological weapons have been discovered in the hands of several potential terrorists, including U.S. domestic terrorists.

Case: Goiânia accident (1987)

No actual radiological weapon has ever been used in a criminal or terrorist attack. However, one radiological hazardous material incident demonstrates the possible health effects of a major successful attack. On September 13, 1987, medical equipment was stolen from an abandoned hospital in Goiânia, Brazil. The thieves were seeking metal for salvage and were unaware that they had taken a powerful radioactive source. The protective casing for the equipment's caesium chloride source was cracked open with a hammer and the deadly material dispersed through homes and businesses. The victims, some of whom were children, and none of whom were aware of the danger, handled the radioactive caesium and in some cases painted it on their bodies or ate it.

The danger was not recognized for more than two weeks, when doctors identified the radioactive material. When the incident was made public, local medical facilities were then overwhelmed by approximately 130,000 persons seeking medical care. Eventually, 249 victims were found to be contaminated, four of whom died. Extensive clean-up work required widespread radioactive monitoring, demolition of a number of buildings, excavation of contaminated soil, and disposal of large amounts of radioactive waste.

The Goiânia accident represents nearly a worst case example of radioactive contamination. The material involved was especially dangerous and the danger was undetected for several weeks. Victims had ongoing close contact with the radioactive material, including ingestion. A dirty bomb attack would likely be detected immediately, and a much timelier and more effective response conducted. Despite the seriousness of this incident, there were only four deaths, although cleanup was difficult and expensive. Public fear of radiation led to large numbers of unexposed but concerned persons demanding medical treatment.

Nuclear weapons are potentially the deadliest terrorist tools. Unlike the radiological "dirty bombs" described above, nuclear weapons create very large explosions capable of creating widespread damage and many casualties over a large area. The great destructive potential of these devices make them very desirable for terrorist groups that wish to cause massive and indiscriminate casualties. Fortunately, nuclear weapons are difficult to build, especially because they require the use of rare and carefully guarded materials. Although several terrorist groups have actively sought to acquire nuclear weapons, no terrorist organization is known to have succeeded in doing so.

The importance of the terrorist nuclear threat is not that such an attack is likely, but that it is possible, and that the damage caused by such an attack would be immense. Nuclear weapons cause damage by releasing enormous amounts of heat, by creating powerful explosive shock waves, by releasing damaging radiation, by disrupting electronic devices, and in some cases, by creating radioactive dust, called fallout, that drifts downwind from nuclear explosions. Nuclear weapons vary greatly in their power and effects: the weapons most likely to be used by terrorists are very dangerous, but are still far less powerful than the strategic nuclear weapons possessed by nations such as the United States, Russia, and China.

For more detail on nuclear weapons and their effects, see the Nuclear Attack section of this document.

Case: Bombings of Hiroshima and Nagasaki (1945)
Although the nuclear attacks against Japan at the end of World War II were military strikes rather than terrorism or criminal activity, these cases are included because these are the only examples of nuclear weapons used against populated areas. The attacks, each using one nuclear bomb, destroyed the centers of the cities of Hiroshima and Nagasaki, though not their outskirts. At Hiroshima, 4.7 square miles of the city were destroyed and approximately 100,000 residents were killed. At Nagasaki, 1.8 square miles were destroyed and approximately 60,000 died. In both cases, the greatest cause of damage and destruction was intense heat and fire. The weapons used against the cities of Hiroshima and Nagasaki were weak by modern military standards, but were approximately the strength of the most likely types of terrorist nuclear weapons. These attacks provide a very rough guide as to the damage and casualties to be expected from a terrorist nuclear attack against a medium-sized city.

Sabotage is the destruction of property or the disruption of operations in an attempt to harm a business, government, or other entity. Attackers who use sabotage are called saboteurs. Sabotage often overlaps with, and can be difficult to distinguish from, other terrorist or criminal tactics. For example, explosives can be used to destroy vehicles or infrastructure, or chemical poisons can be used to contaminate food and medicine. The principal identifying characteristic of sabotage is that the attack is unusually not intended to harm large numbers of people, but rather to cause economic harm or embarrassment to the target. Where deaths or injuries do occur, they are usually incidental, rather than the purpose of the attack. Past sabotage tactics have included the toppling of electrical power pylons, the burning of vehicles, destruction of railroads and bridges, and contamination of food and medicine.

Many single-issue terrorists, including ecological extremists and anti-abortion radicals, have used sabotage widely. These groups have usually preferred to destroy property rather than to kill people. Most other terrorists tend to avoid sabotage as they seek the media coverage that results from numerous casualties. Sabotage by non-terrorist criminals is difficult to characterize, as it ranges from planned campaigns by organized labor groups, to one-time extortion plots, to attacks by mentally disturbed individuals.

Case: Byron Center Meat Tampering (2003)
In January 2003, a disgruntled employee intentionally contaminated 250 pounds of ground beef sold at a local supermarket in Byron Center (Kent County), Michigan. The meat was poisoned with insecticide containing harmful amounts of nicotine. The attacker was seeking revenge on his supervisor, whom he hoped would be blamed for the illnesses. Although the ground beef contained potentially lethal doses of toxin, there were no fatalities resulting from the attack. Investigation did identify 92 individuals sickened by the poison. The attacker

was convicted and sentenced to seven years in prison. This incident demonstrates the willingness of some saboteurs to endanger the lives of numerous bystanders in pursuit of their goals. In this case, the attacker had no specific interest in harming the poisoning victims, except to use them to embarrass a personal enemy.

Case: Pontiac School Bus Bombings (1971)
On August 30, 1971, ten Pontiac school buses were bombed and destroyed in response to a controversial, court-ordered busing plan to integrate Pontiac schools. Authorities believe that several individuals slipped through a hole cut in the wire fence that surrounded the Pontiac bus depot, and placed dynamite under the buses. The explosion and fire destroyed the buses and focused national attention on Pontiac and the school busing issue. Subsequent attempts to overturn the Pontiac busing plan failed, and eventually 70 other school districts across the country were ordered to implement similar busing plans to achieve racial integration in schools. The Pontiac bombers, later apprehended and convicted of the attack, were identified as members of the Ku Klux Klan.

Suggested case for readers' further study: Tylenol cyanide poisonings (an example of a major impact on industry, and an unknown perpetrator with an undetermined motive).

Cyber-attack is a new category of terrorist and criminal threat. Cyber-attacks involve the use of computers, electronic devices, and/or the Internet to attack computer systems. Examples of some types of cyber-attacks include computer viruses, which damage many infected computers, denial-of-service attacks, which shut down a targeted website, and hacking attacks, which damage sensitive information. These attacks may be used as part of extortion schemes, to undermine public confidence in the target's security, as a form of technological vandalism, or as military sabotage. As defined in Michigan's new response plan (see the Programs and Initiatives Subsection), a significant cyber disruption event is defined as "an event that is likely to cause, or is causing, harm to critical functions and services across the public and private sectors by impairing the confidentiality, integrity, or availability, of electronic information, information systems, services, or networks; and/or threaten public safety, undermine public confidence, have a negative effect on the state economy, or diminish the security posture of the state."

Early cyber-attacks were primarily conducted by amateur computer "hackers" operating individually or in small teams. More recently, well organized groups of profit-driven professional cyber-attackers have developed. These teams of cyber-saboteurs can operate globally, attacking targets anywhere in the world through the Internet. Their customers include organized crime, national governments, and possibly terrorist organizations. These professional cyber-attackers can be very effective because they control large networks of "zombie" computers called "botnets." These are computers taken over without their owners' knowledge and controlled remotely, often for criminal purposes.

Another possible source of cyber-attacks are "hacktivists," computer criminals motivated by a political cause rather than by a profit motive. Several global networks of hacktivists have been created, including "Anonymous" and "Lutzsec." These loosely organized groups include members in multiple countries who coordinate their efforts online. There are also a number of nationalist hacktivist organizations, some of which may be sponsored by national intelligence services. Hacktivists groups are difficult to disrupt, both because of the challenge in determining the real identity of group members, and because they may be located in countries which refuse to cooperate with international law enforcement. Hacktivists have generally confined their cyber attacks to vandalism of websites, denial of service attacks, and theft of personal information. There is however, the potential for extremist members of these politically-motivated groups to shift their activities to more destructive cyber-terrorism.

National governments are also developing sophisticated cyber-attack capabilities, both to support espionage programs and to damage the computer networks of enemies. Cyber-attacks backed by extensive national military and intelligence resources could be especially destructive and difficult to counter. One new cyber-attack capability which appears to have been deployed by government-sponsored programmers is the ability to cripple or

destroy industrial machinery by taking over the software that controls the machines. Cyber-attacks on these "industrial control systems" could be used to damage critical infrastructure such as electrical grids, water treatment systems, and fuel pipelines as well as to attack industrial targets. National cyber-attack capabilities are also expected to include efforts to disrupt secure national networks such as those used for banking and by law enforcement. A cyber war between nations with sophisticated cyber-attack capabilities could be very damaging, even to innocent bystanders in the conflict.

An analysis of cyber-attacks usually requires special resources to identify and report details about ongoing or past significant incidents that involve attacks upon or exploitation of computer networks or communications system. The Michigan Intelligence Operations Center especially tracks any such operations that impact the U.S. homeland or national security interests.

Here are some examples of information that may be noted and reported about cyber-attacks:

- What type of activity occurred?
    - Data exfiltration
        - If data was exfiltrated, how much and what type?
        - To what IP (internet protocol) address?
    - Malicious file infiltration
    - Malware detection
    - Botnet activity
    - Spear Phishing
- What attack vector was used?
- What vulnerability did the threat actors exploit/attempt to exploit?
    - Known vulnerability for which a patch exists (include Common Vulnerabilities and Exposures [CVE] number if known)
- Upon gaining access, what did the threat actors do?
    - Scan for vulnerabilities and attempt to move laterally across the network
    - Host malware on a system
    - Compromise Active Directory server / Domain controller
    - Create additional accounts
    - Exfiltrate username and password hashes
    - Exfiltrate specific types of documents (either by name/subject or file type)
    - Exfiltrate whatever files and information they could get access to
- IP addresses involved in malicious activity?
    - The number of times the IP was involved in an event on that given day
    - The country associated with the IPs
- What malicious websites or domains were involved?
    - Indicate what IP address the domain resolved to at the time of the incident
    - Domain/IP registration information if available, including country of origin
    - Other domains hosted by malicious IPs
- When did the activity occur?
    - In addition to the date, include the period of time (the hours) from when the activity was detected to when it stopped
    - Each day the IP was involved, if across multiple days
- Phishing and Spear Phishing
    - E-mail header information
        - Sending IP
        - Mail relays involved
        - True email address (if message was spoofed)
    - Subject line

    - Attachments (more information in the next bullet section for malicious attachments)
    - Hyperlinks in the email, including the actual destination for any spoofed links
    - Text from the body
    - For spear phished individuals, include how the malicious actor attempted to bait their target
- What malicious code/software was detected or what indicators were associated with malicious files?
    - File name
    - File size
    - Hash values (e.g. MD5, SHA-1, ssdeep)
    - Timestamps
    - Additional malware information
- What botnet(s) were associated with the incident?

It is important to have some knowledge of a few key terms associated with this threat:

Adware: A form of software that displays advertising content in a manner that is potentially unexpected and unwanted by users, and which may also include various user-tracking functions (similar to spyware).

Botnet: The word BOTNET is short for the combination of the word robot and network. The term often applies to groups of computer systems that have had malicious software installed by worms, Trojan horses or other malicious software that allows the "botnet herder" or botnet's originator to control the group remotely.

Cookie: A small text file that is placed on a computer's hard drive by a web site, in order to allow that site to retain and use information about the user (and the user's activities) at a later time.

Keystroke logger: Any method that allows the recording or interpretation of which keys have been pressed by a user on the person's computer keyboard, typically without the person's awareness or consent. The methods may include software or hardware that records all typed information, possibly including the analysis of video and acoustic information about the user's behavior, but often accomplished by means that make use of the computer itself to relay information to a remote person or machine, for later use.

Malware: Software that can destroy your data, affect your computer's performance, cause a crash, or even allow spammers to send email through your account.

Pharming: Arranging for a web site's traffic to be redirected to a different, fraudulent site, either through a vulnerability in an agency's server software or through the use of malware on a user's computer system.

Phishing: the attempt to trick someone into providing confidential information, or doing something that normally wouldn't or shouldn't be done. For example, phishing could involve sending an e-mail that falsely claims to be from an established legitimate enterprise, in an attempt to scam the user into surrendering private information that will be used for identity theft.

Social engineering: In the context of cyber-security, this refers to an effort to psychologically manipulate a person, especially through misrepresentation or deception (as in a con game), to gain access to information. The manipulation often relies on the trusting nature of most individuals, or makes use of many persons' natural reluctance to offend others or to appear too mistrustful. The ruse may involve creating impressions that make things appear more benevolent, trustworthy, and reliable than they actually are. Some schemes are very complex, and involve several stages of manipulation over a substantial period of time.

Spear phishing: A form of phishing that targets a specific individual, company, or agency, usually relying on an accumulation of information to make subsequent ruses more effective when further probing the target, until a successful security breach finally becomes possible.

Spoofing: (1) Attempting to gain access to a system by posing as an authorized user. Synonymous with impersonating, masquerading or mimicking. (2) Attempting to fool a network user into believing that a particular site was reached, when actually the user has been led to access a false site that has been designed to appear authentic, usually for the purpose of gaining valuable information, tricking the user into downloading harmful software, or providing funds to the fraudsters.

Spyware: Software that allows others to gain private information about a user, without that person's knowledge or consent, such as passwords, credit card numbers, social security numbers, or account information.

Trojan (or Trojan Horse): A program that, although neither replicating nor copying itself, performs some illicit activity when it is run. It stays in the computer doing its damage or allows somebody from a remote site to take control of the computer.

Virus: A program or code that attaches itself to a legitimate, executable program, and then reproduces itself when that program is run.

Worm: A self-contained program (or set of programs) that is able to spread copies of itself to other computer systems—usually through network connections or e-mail attachments.

Case: July 2009 Cyber-Attacks (2009)

On the 4th of July, 2009, a series of cyber-attacks were directed against computer systems in the United States and in South Korea. Targets included the websites of the U.S. State Department, the U.S. Department of Defense, the White House, numerous South Korea government agencies, a large bank, and a major South Korean media company. The attacks were designed to shut down the targeted websites by overloading them with traffic. This was accomplished with a "botnet" of computers infected by a computer virus. Thousands of computers were hijacked and used in these attacks without their owners' knowledge. The cyber-attack software was also designed to damage the computers in the botnet several days after the start of the attack. Some experts believe that the attack was sponsored by the government of North Korea, perhaps with the help of criminal networks operating outside of that country. As with many cyber-attacks, it has been impossible to definitively prove who was responsible for the attacks. This case demonstrates the significant economic and governmental disruption which can be caused by even primitive cyber-attacks. It also demonstrates that the geographic locations of the cyber-attackers and of their targets are largely irrelevant. Attacks can be launched from anywhere, to anywhere, through the use of the Internet.

Case: Stuxnet (2010-Present)

First discovered in June of 2010, Stuxnet is a highly sophisticated cyber-attack program. This "computer worm" software has been designed to infect industrial control systems created by the Siemens Corporation. On most computers, the Stuxnet worm stays hidden and does no damage. However, if the Siemens control software is connected to certain types of motors, the worm conducts a cyber-attack on the infected system. The targeted motor is ordered to rapidly change speeds, which will destroy certain types of connected industrial equipment. Meanwhile the safety mechanisms on the equipment are disabled, and monitors will show motor performance as completely normal, even as the equipment is being destroyed. It is believed that Stuxnet was designed specifically to damage uranium processing equipment operated by the government of Iran. Substantial harm was apparently inflicted on its processing facility at Natanz. The creators of Stuxnet are unidentified, but given the sophistication of the software, and the care with which only Iranian government systems were targeted, it is considered likely that at least one national intelligence service was involved in creating the worm. Several governments have expressed an interest in damaging Iran's nuclear industry in order to stall the creation of Iranian nuclear weapons. The case provides an example of the sophisticated cyber-attack tools which may be deployed by national governments. It also provides the first example of cyber-attack software capable of causing physical damage, not merely theft or destruction of data.

Case: Flame Malware (widely publicized in 2012)
Flame (also known as Skywiper) is complex, targeted malware which became widely known in 2012, although the worm was already at least two years old by that point. Used for espionage activities, it attacks computers that use the Microsoft Windows operating system. It can spread through local area networks and through USB sticks ("thumb drives"), and reportedly has the ability to record a user's keyboard activity as well as the audio and visual output of the computer (such as Skype conversations). In addition to relaying this information to distant observers, it reportedly has the ability to delete large amounts of information from the infected system.

Possible Terrorist/Criminal Targets
Terrorists typically select targets that will generate the maximum possible media coverage, but the specific types of targets selected by terrorists and criminals depend entirely on the goals of the attackers. For nationalist, left-wing, and right-wing terrorists, the preferred targets are usually buildings or people with strong symbolic meaning for their enemies. These terrorists may attack government buildings, strike public monuments, or assassinate well-known leaders. Single-issue terrorists tend to target facilities or individuals directly associated with their specific cause. For example, anti-abortion terrorists might target abortion clinics, anti-Jewish terrorists might target synagogues, and animal rights terrorists may target animal research centers. Finally, religious extremist terrorists tend to emphasize killing or injuring large numbers of victims in a spectacular manner. These terrorists might be expected to target schools, airports, mass-transportation systems, sporting events, places of worship, or entire cities.

Most terrorists will usually seek out targets that are poorly defended by law enforcement, security screening, or other protective measures. Such "soft" targets offer the opportunity to do the maximum possible damage. Even terrorists who do not intend to survive their attack want to accomplish their mission, and well-protected targets can make that difficult to achieve. Terrorists rarely feel the need to strike only one specific target, so they will examine multiple targets until they find one that is vulnerable.

Targets for non-terrorist criminals are difficult to identify because criminals may have a wide range of motivations, including financial gain, personal revenge, a desire for fame, or mental illness. Criminals are generally more likely to choose targets that they are personally connected with, as when criminal employees target their workplace or criminal students target their own school building.

Impact on the Public
The specific impact of terrorism or similar criminal activities would depend on the nature of the terrorist targets and the type of weapons used against those targets. Given the wide range of possibilities, it is difficult to generalize about damage or casualties. In a worst case scenario, a terrorist or criminal attack could cause significant damage to people, property, and to the economy. Infrastructure, such as transportation, computer networks, or communications might be damaged or overwhelmed by a fearful population. Worst case scenarios, however, are unusual. Most attacks will do little damage and only a very few will cause mass casualties. One likely impact of terrorism on the public would be an increase in fear, uncertainty, and inconvenience. Terrorism is, after all, intended to cause terror. In some cases, innocent citizens may suffer misguided retaliation if they are identified with an ethnic group or political movement held responsible for terrorism. Public impact may also be increased by the effect of government anti-terrorism programs, as demonstrated by the inconvenience created by increased airport security measures.

Impact on Public Confidence in State Governance
Public reaction to terrorist attacks would vary depending on the effectiveness of the attack and the type of target. It is possible that state government would be held accountable for failing to stop a terrorist plot, though counter-terrorism is generally considered to be a federal government responsibility. Governments may also be pressured to create new legal restrictions and law enforcement measures in response to a terrorist attack. Such measures would be expected to create public opposition from citizens who feel their rights violated by counter-terrorism

efforts. Finding the correct balance between civil liberties and public security is likely to remain a difficult challenge.

Impact on Responders
Responders may face difficult and unexpected challenges following a terrorist or criminal attack, especially if the attack involves mass casualties or uses chemical, biological, radiological, nuclear, or cyber attack. Terrorists, and criminals who conduct terrorist-like violent attacks, may behave very differently from other types of criminals with which responders are familiar. Terrorist weapons may pose a direct hazard to the life and safety of responders, especially in the case of secondary devices specifically targeted on those responders.

Impact on the Environment
Terrorist and violent criminal attacks are very rarely targeted specifically on the environment, but environmental damage is possible as an indirect consequence of an attack. This would be especially true in the case of chemical, radiological, biological, or nuclear weapons which could contaminate a significant area for an extended period of time. Damage to infrastructure may also cause environmental problems, as in the case of an oil pipeline sabotaged with explosives or a metropolitan water treatment system disabled by cyber-attack. Please refer to the sections on dam failures, energy emergencies, fires, hazardous materials, infrastructure failure, nuclear attack, oil and natural gas pipeline and well accidents, public health emergencies, and transportation accidents for more examples of the type of impacts that may result from terrorism or major criminal incidents.

Programs and Initiatives
(Note: Refer to the Weapons of Mass Destruction Attack Procedures section of the Michigan Emergency Management Plan for a comprehensive list of federal and state response assets that can be mobilized for incidents of sabotage / terrorism involving weapons of mass destruction.)

Homeland Security Act of 2002

The Homeland Security Act of 2002, Public Law 107-296, established the Department of Homeland Security with the mandate and legal authority to protect the American people from the continuing threat of terrorism. In the act, Congress assigned the DHS the primary mission to (1) prevent terrorist attacks within the United States, (2) reduce the vulnerability of the United States to terrorism at home, (3) minimize the damage and assist in the recovery from terrorist attacks that occur, and (4) act as the focal point regarding natural and manmade crises and emergency planning.

Public Health Security and Bioterrorism Preparedness Act of 2002

The events of September 11, 2001, reinforced the need to enhance the security of the United States food supply. Congress responded by passing the Public Health Security and Bioterrorism Preparedness and Response Act of 2002, Public Law 107-188, which President Bush signed into law on June 12, 2002. The Act is divided into the following five titles:

- Title I - National Preparedness for Bioterrorism and Other Public Health Emergencies
- Title II - Enhancing Controls on Dangerous Biological Agents and Toxins
- Title III - Protecting Safety and Security of Food and Drug Supply
- Title IV - Drinking Water Security and Safety
- Title V - Additional Provisions

This federal investment, combined with the efforts of states, local government and private sector entities, is increasing the capacity of our nation's public health system for confronting possible bioterrorism incidents as well as other health threats. These efforts can reduce the consequences of bioterrorism, especially through the development of new countermeasures to treat or prevent diseases that might be used by terrorists. At the same

time, these efforts increase the nation's capacity to deal with all public health emergencies, including chemical or nuclear terrorism, natural outbreak of disease, or other mass casualty events.

The Maritime Transportation Security Act of 2002

The Maritime Transportation Security Act of 2002 (MTSA), Public Law 107-295, signed on November 25, 2002, is designed to protect the nation's ports and waterways from terrorist attacks. This law is the U.S. equivalent of the International Ship and Port Facility Security Code (ISPS), and was fully implemented on July 1, 2004. It requires vessels and port facilities to conduct vulnerability assessments and develop security plans that may include passenger, vehicle, and baggage screening procedures; security patrols; establishing restricted areas; personnel identification procedures; access control measures; and installation of surveillance equipment. By creating a consistent security program for all our nation's ports, we are better able to identify and deter threats. The MTSA also required the establishment of committees in all the nation's ports to coordinate the activities of all port stakeholders, including other federal, local and state agencies, industry, and the boating public. These groups, called Area Maritime Security Committees, are tasked with collaborating on plans to secure their ports so that the resources of an area can be best used to deter, prevent, and respond to terror threats.

Terrorism Risk Insurance Program

On November 26, 2002, President Bush signed into law the Terrorism Risk Insurance Act of 2002, Public Law 107-297. The law establishes a temporary federal Terrorism Insurance Program that provides for a transparent system of shared public and private compensation for insured losses resulting from acts of terrorism, in order to protect consumers by addressing market disruptions and ensure the continued widespread availability and affordability of property and casualty insurance for terrorism risk. In addition, it allowed for a transitional period for the private markets to stabilize, resume pricing such insurance, and build capacity to absorb any future losses, while preserving state insurance regulation and consumer protections.

Presidential Decision Directive 39

In response to the World Trade Center and Oklahoma City bombings and the Tokyo subway sarin gas attack, in 1996 President Clinton signed Presidential Decision Directive (PDD) 39, U.S. Policy on Counter-terrorism, ordering federal agencies to prepare for nuclear, biological, and chemical attacks from inside the country as well as abroad. Although every presidential administration since the early 1980s has issued similar directives, PDD 39 was the first to make terrorism a top priority, and the first to recognize that significant terrorism threats exist from within. PDD 39 designated the FBI as the lead federal agency for the crisis management phase of terrorism incidents, and FEMA as the lead agency for post-incident consequence management. It also created the nationwide Metropolitan Medical Response Systems (MMRS – see description below) and significantly expanded the anti-terrorism responsibilities of a number of other agencies.

Presidential Decision Directive 62

In May 1998, President Clinton issued Presidential Decision Directive (PPD) 62, Combating Terrorism, which reinforces the mission of federal departments and agencies charged with roles in defeating terrorism.

Homeland Security Presidential Directive (HSPD)-5

HSPD-5 was issued on February 28, 2003 and is intended to enhance the ability of the United States to manage domestic incidents (which include terrorist attacks, major disasters, and other emergencies) by establishing a single, comprehensive National Incident Management System (NIMS). Refer to the Michigan Emergency Management Plan.

Homeland Security Presidential Directive (HSPD)-7

HSPD-7 was issued on December 17, 2003 and establishes a national policy for federal departments and agencies to identify and prioritize U.S. critical infrastructure and key resources and to protect them from terrorist attacks. (Note: the State of Michigan is actively involved in the critical infrastructure protection process. Refer to the Weapons of Mass Destruction Attack Procedures in the Michigan Emergency Management Plan.)

Homeland Security Presidential Directive (HSPD)-8

HSPD-8 was issued on December 17, 2003 and establishes policies to strengthen the preparedness of the United States to prevent and respond to threatened or actual domestic terrorist attacks, major disasters, and other emergencies by requiring a national domestic all-hazards preparedness goal, establishing mechanisms for improved delivery of federal preparedness assistance to states and local governments, and outlining actions to strengthen preparedness capabilities of federal, state, and local entities.

Presidential Policy Directive 8 (PPD-8)

PPD-8 was issued on March 30, 2011, to facilitate an integrated, all-of-nation, "whole community," capabilities-based approach to preparedness. It involves federal partners, state, local and tribal leaders, the private sector, non-governmental organizations, faith-based and community organizations, and the general public, to keep people and communities safe and prevent the loss of life and property when disasters strike. Implementation of the PPD-8 will require extensive outreach, collaboration, and input from stakeholders at all levels of government, the private and non-profit sectors, and also from the public.

Homeland Security Operations Center (HSOC)

The HSOC is the primary national-level multi-agency hub for domestic incident management, operational coordination, and situational awareness. It is a standing 24/7 interagency organization fusing law enforcement, national intelligence, emergency response, and private sector reporting. The HSOC facilitates homeland security information sharing and operational coordination with other federal, state, local, tribal, and nongovernmental EOCs.

National Counterterrorism Center (NCTC)

The NCTC is the primary federal organization for analyzing and integrating all intelligence possessed or acquired by the U.S Government pertaining to terrorism and counterterrorism. The NCTC may (consistent with applicable law) receive, retain, and disseminate information from any federal, state, or local government, or other source necessary to fulfill its responsibilities. The NCTC serves as the central and shared knowledge bank on known and suspected terrorists and international terror groups, as well as their goals, strategies, capabilities, and networks of contacts and support. The NCTC ensures that agencies have access to and receive the all-source intelligence support needed to execute their counterterrorism plans or perform independent, alternative analysis.

National Infrastructure Protection Center (NIPC)

Established in February 1998 by the FBI and expanded in scope and mission by PDD 63, the National Infrastructure Protection Center (NIPC) serves as the national critical infrastructure threat assessment, warning, vulnerability, and law enforcement investigation and response entity. PDD 63 specifically assigned the following missions to the NIPC:

- Detect, deter, assess, warn, respond, and investigate unlawful acts involving computer and information technologies and unlawful acts, both physical and cyber, that threaten or target critical infrastructures.
- Manage computer intrusion investigations.
- Support law enforcement, counter-terrorism, and foreign counter-intelligence missions related to cyber crimes and intrusion.
- Support national security authorities when unlawful acts go beyond crime and are found to be foreign-sponsored attacks on U.S. interests.
- Coordinate training for cyber investigators and infrastructure protectors in government and the private sector.

The NIPC, through its Awareness of National Security Issues and Response (ANSIR) Program, provides unclassified national security threat and warning information to U.S. corporate security directors and executives,

law enforcement, and other government agencies. This information is disseminated nationwide via established e-mail and fax networks. Each of the FBI's field offices has an ANSIR coordinator and is equipped to provide national security threat and awareness information on a regular basis to corporate recipients within their jurisdiction. (Note: Individuals and U.S. corporations wishing to become direct recipients of FBI / ANSIR communications should provide business card information, i.e., company name, address, phone, facsimile, etc. to ansir@leo.gov for processing, with a brief description of the product and/or service provided by the individual or organization.)

Metropolitan Medical Response System (MMRS)

The MMRS was administered by the United States Department of Homeland Security, to build and sustain national preparedness capabilities against risks associated with potential terrorist attacks. The MMRS supports the integration of emergency management, health, and medical systems into a coordinated response to mass casualty incidents caused by any hazard. Successful MMRS grantees reduce the consequences of a mass casualty incident by having augmented their existing local operational response systems in advance of a hazardous event. MMRS sub-grantees collaborate with local, regional, and state health and medical partners, and leverage other federal programs, in order to coordinate and support plans, processes, and strategies related to response needs that include continuity of government, continuity of operations, equipment and supplies procurement, and emergency triage and medical services, among others. As of 2012, there are currently 124 MMRS jurisdictions across the country that are eligible for funding. Michigan's MMRS jurisdictions are Detroit, Grand Rapids, and Warren, which perform most of their MMRS functions in coordination with local, regional, and state health department programs.

Strategic National Stockpile (SNS)

No one can anticipate exactly where a terrorist incident may occur, and few agencies have the resources to create a sufficient pharmaceutical stockpile on their own. Local health departments, hospitals, and the Michigan Department of Community Health have access to limited supplies of pharmaceutical inventories. However, the U.S. Centers for Disease Control (CDC) Strategic National Stockpile—a national repository of pharmaceuticals and life-saving medical materials—can be rapidly delivered to a site of biological or chemical terrorist attack.

Urban Search and Rescue (US&R) Task Forces

FEMA has developed, equipped, and trained a cadre of 28 National Urban Search and Rescue (US&R) task forces, strategically located in 19 states around the country, to provide assistance in incidents involving structural collapse. Any of the 28 task forces can deploy to a major disaster area to provide supplemental assistance in structural rescue. The US&R task forces can help locate, extricate, and provide onsite medical treatment to victims trapped in collapsed structures. These task forces are staffed primarily by local fire department and emergency services personnel who are experienced and trained in collapsed structure search and rescue operations. Many of the teams now carry the added responsibility of responding to hazardous material / WMD incidents, swift water rescue calls, and specialized technical rescue emergencies. Although Michigan does not have a certified task force within its borders, task forces are located in nearby Miami Valley, Ohio and Marion County, Indiana. (However, Michigan has recognized the need to support an intra-state team, Michigan Urban Search and Rescue (MUSAR), that is a vital component of its intra-state response capability.)

Federal Homeland Security Grants

Since the terrorist attacks of September 11, 2001, the federal government has made available billions of dollars in grants, under a variety of grant programs to state, local, and tribal governments nationwide, to aid in preventing, mitigating, preparing for, responding to, and recovering from terrorist attacks. This funding has been used to hire additional personnel, buy necessary equipment and supplies, develop terrorism plans and procedures, conduct targeted training for responders, hold terrorism-related exercises, and take other necessary actions to develop and enhance local and state emergency management and homeland security capabilities. The federal grant funding stream and processes continue to evolve from year to year, based on national priorities and national and international conditions.

Emergency Management Assistance Compact (EMAC)

The EMAC is an interstate mutual aid agreement that allows states to share resources and assist one another in responding to natural and man-made disasters. The strength of EMAC and the quality that distinguishes it from other plans and compacts lies in its governance structure, its relationship with federal organizations, states, counties, territories, and regions, and the ability to move just about any resource one state has to assist another state, including medical resources. All fifty states, plus four territories, have joined this compact through enacting legislation. Michigan became the 43rd participating state in January 2002. Although the EMAC is not terrorism specific, it most likely would be activated in the event of a major sabotage/terrorism incident within the United States.

Computer Emergency Response Team / Coordination Center

The Computer Emergency Response Team (CERT) Coordination Center is a center of Internet security expertise located at the Software Engineering Institute, a federally funded research and development center at Carnegie Mellon University in Pittsburgh, Pennsylvania. The CERT was established at the behest of the Defense Advanced Research Projects Agency (DARPA), following a November 1988 Internet virus incident, to coordinate communication among experts during security emergencies and to help prevent future incidents. The CERT has helped to establish a number of other computer response teams, and the CERT's incident handling practices have been adapted by numerous response teams around the world. The CERT studies Internet security vulnerabilities, handles computer security incidents, publishes security alerts, researches long-term changes in networked systems, and develops information and training in network security for technical staff, managers, and system administrators.

Michigan Executive Directive 2002-1

On January 24, 2002, a Michigan Executive Directive issued by Governor John Engler (1) designated the State Director of Emergency Management as the State Director of Homeland Security, (2) designated the Emergency Management and Homeland Security Division, Department of State Police as the focal point for homeland security issues in Michigan, (3) redefined the mission of the Michigan Homeland Security Task Force, and (4) directed state agencies to actively support the Task Force and its ongoing activities. (Note: ED 2002-1 was repealed by Executive Order 2003-6, described below.)

Michigan Executive Order 2003-6

On April 15, 2003, a Michigan Executive Order issued by Governor Jennifer Granholm established (1) the office of Assistant Adjutant General for Homeland Security (within the Department of Military and Veterans Affairs) to advise the Governor and state agency directors on the development of homeland security policies, programs, and procedures, (2) the Michigan Homeland Protection Board (within the Department of State Police) to develop, implement, and revise a state homeland security strategy, and (3) the Michigan Homeland Security Advisory Council to advise the Board and provide input, advice, and recommendations on homeland security issues. EO 2003-6 also abolished the Michigan Homeland Security Task Force established by Executive Directive 2002-1, re-affirmed the existing homeland security roles and responsibilities within the Department of State Police, and directed state agencies to actively participate in state homeland security efforts.

Michigan Executive Directive 2005-9

On September 29, 2005, a Michigan Executive Directive issued by Governor Jennifer Granholm adopted the National Incident Management System (NIMS) as the state standard for incident management in Michigan.

Michigan Emergency Management Assistance Compact (MEMAC)

The statewide mutual-aid assistance compact, authorized under 1976 PA 390, as amended, allows participating jurisdictions to render or receive assistance in time of crisis, and to share vital public safety services and resources more effectively and efficiently. The MEMAC is designed specifically for those situations in which (1) a participating jurisdiction has exhausted its local resources (including those available through local / regional

mutual aid or reciprocal aid compacts or agreements), or (2) its resources are inadequate or overwhelmed in response to a threat or event being faced, and it requires additional resources (provided in a timely manner) to protect public health and safety, property, or the environment. (The EMHSD/MSP administers the MEMAC on behalf of the State of Michigan and is responsible for processing requests for resources by participating jurisdictions.)

Michigan State Agencies

Sabotage / terrorism is being addressed on a variety of fronts within Michigan State Government. The Michigan Department of State Police oversees and coordinates state agency actions related to homeland security and terrorism response, including the investigation of suspected or potential criminal enterprises and activities that might involve sabotage or terrorism. In addition, the State Police (in conjunction with other state agencies as well as federal and local counterparts) continuously prepares for terrorist incidents through emergency planning, training, information sharing, and exercising efforts. All state agencies have a role to play in the State's prevention, mitigation, preparedness, response, and recovery plans for sabotage/terrorism. Some state agencies, such as the Michigan National Guard and the Departments of Agriculture and Rural Development, Environmental Quality, Transportation, and Community Health (to mention a few), have especially critical roles in the State's response and recovery efforts. An overview of the State's anti-terrorism procedures can be found in the Michigan Emergency Management Plan (MEMP).

Michigan Regional Response Team Network (RRTN)

As part of its anti-terrorism response strategy, the State of Michigan has established the Michigan Regional Response Team Network (RRTN). The RRTN now includes 16 teams, geographically positioned around the state, that can respond to a weapons of mass destruction incident anywhere in Michigan within two hours of activation, to provide support to the local incident commander and appropriate federal agencies responsible for the mitigation and investigation of such an incident. These regional teams include local police, fire, and medical agencies, with support from the Michigan Urban Search and Rescue Team (MUSAR) and local and state bomb squads. The RRTN can provide technical assistance and a variety of support services, including scene reconnaissance, stabilization and rescue, crime scene and evidence preservation, mass decontamination, and coordination with the FBI and other involved federal agencies. The RRTN is activated through the State Emergency Operations Center.

Michigan Urban Search and Rescue (MUSAR)

The MUSAR Team is a privately funded organization working in cooperation with the fire service, local emergency management, the MSP, and private sector agencies, to provide a statewide capability for specialized response to structural collapse emergencies and incidents requiring specialized training in search and rescue. MUSAR is organized into four specialized teams—a Search Team, a Rescue Team, a Medical Team, and a Technical Team. In an event that involves the structural collapse of a building, MUSAR can provide immediate statewide response assistance upon activation through the State Emergency Operations Center. The Technical Team can also provide assistance in situations involving toxic chemicals.

51st Weapons of Mass Destruction Civil Support Team (WMD CST)

Stationed at the Michigan National Guard's Fort Custer Training Center in Augusta, the 51st WMD CST was created to augment local and regional terrorism response capabilities in attacks known or suspected to involve WMD. The CST consists of Michigan National Guard personnel, highly trained in the areas of chemical weapons, biological weapons, radiological materials, nuclear weapons, and/or high yield explosives (CBRNE), and capable of being en route to the site of an attack to support civil authorities within hours following notification.

Specifically, the 51st CST deploys to an area of operation to (1) assess a suspected CBRNE event in support of a local Incident Commander, (2) advise civilian responders regarding appropriate response actions, and (3) facilitate requests for assistance to expedite the arrival of additional state and federal assets to help save lives, prevent

human suffering, and mitigate property damage. Working in support of the Incident Commander, the CST can verify the perimeter of the exclusion zone and send teams into the "hot zone" to conduct reconnaissance, survey, detection, and sampling missions. The Team is trained to the Hazardous Materials Technician (and above) level and maintains highly specialized technical equipment designated for use with each type of WMD/CBRNE.

The Team is available on-call 24 hours-a-day, seven days-a-week. The 51st WMD CST is activated through the State Emergency Operations Center (SEOC), or through a lead emergency response organization's Request for Assistance (RFA), submitted to the Michigan National Guard's Joint Operations Center (JOC).

Michigan Epidemiological Response and Investigation Team (MERIT)

The MERIT was created by the Michigan Department of Community Health (MDCH) to provide a quick response to bio-terror attacks and other public health emergencies, and to coordinate resources and expertise at local, state, and federal levels across a wide range of public health disciplines. The MERIT consists of personnel from the MDCH Bureau of Epidemiology (Infectious Disease Physician, Communicable Disease Epidemiologists, Public Health Nurse, etc.), the Michigan Department of Agriculture and Rural Development (MDARD), the MDEQ, the FBI, and/or other state/local law enforcement agencies. The MERIT is activated through the MDCH Emergency Management Coordinator or Office of Public Health Preparedness (OPHP).

Regional Public Health Response Teams (RPHRTs)

Eight Michigan Department of Community Health (MDCH) operational regions have been identified that match the emergency management districts of the Michigan State Police. Through this regional system, the MDCH has established one state-level public health response team (the MERIT), eight regional public health response teams (RPHRTs), and approximately 18 health care worker response teams. Members of these teams may also be part of the Smallpox Response Teams (SRTs) located within the eight regions. These teams allow the rapid mobilization and utilization of public health and health care personnel for a large scale response to a WMD attack or other public health emergency. The regional system will also help to assure the coordination of efforts across regional lines.

Michigan Emergency Preparedness Pharmaceutical Plan (MEPPP)

The purpose of the MEPPP is to provide a comprehensive guide to pharmaceutical resources available at the local, regional, state, and national levels to assist emergency responders and citizens during a CBRNE event or other large-scale disaster within Michigan.

Michigan Emergency Drug Delivery and Resource Utilization Network (MEDDRUN)

During the early stages of a mass casualty incident, the health care system will likely be overwhelmed. In such cases, the availability of critical emergency pharmaceuticals and other vital medical supplies may be compromised. This may be particularly true in a terrorist incident—especially one involving chemical weapons in which the early use of certain antidotes may be life-saving. The MEDDRUN establishes standardized caches of medications and supplies, strategically located throughout Michigan. The MEDDRUN is intended to rapidly deliver these medications and supplies to hospitals and other sites. These caches are based primarily with Michigan's rotary air and other selected emergency medical service (EMS) agencies, to minimize deployment times during an incident.

CHEMPACK

State and local response agencies must be prepared to mount a swift and effective response to acts of terrorism involving nerve agents, as well as situations involving accidental releases of organophosphates, to minimize potential loss of life. The CHEMPACK Project provides the State of Michigan, in collaboration with the federal Centers for Disease Control and Prevention (CDC) and Department of Homeland Security (DHS), with a sustainable, supplemental source of pre-positioned nerve agent / organophosphate antidotes and associated pharmaceuticals that will be readily available for use when local supplies become depleted. The CHEMPACK Project is one component of the Michigan Emergency Preparedness Pharmaceutical Plan (MEPPP), a

comprehensive statewide plan for coordinating the timely application of pharmaceutical resources in the event of an act of terrorism or other large-scale disaster within Michigan.

State Bioterrorism Response Plan

The Michigan Department of Community Health (MDCH) has developed a statewide bioterrorism response plan ("Public Health Planning and Response to Bioterrorism and Public Health Emergencies") under a cooperative agreement with the U.S. Centers for Disease Control. This plan provides a guide for MDCH response to bioterrorism events and covers in detail the following topical areas: communications and notifications, public health surveillance, the biological laboratory response network, emergency management roles and responsibilities, and treatments and prophylaxis of mass casualties. The plan also provides specific recommendations for local communities to prepare for an effective response to a public health emergency.

Terrorism Awareness Video

The "Seven Signs of Terrorism," a terrorism-awareness video created by the Michigan State Police in the aftermath of the September 11, 2001 terrorist attacks, describes the behavior that potential terrorists might exhibit. The video includes information about terrorists conducting surveillance, acquiring supplies, and going through trial runs of an attack, and is based on information used internationally. Originally produced for high school students, it was requested by other groups and is now being distributed on DVD to first responders across the country.

Michigan Homeland Security School Initiative

The Michigan Homeland Security Initiative was an $8.2 million project that identified Michigan school systems as critical infrastructure. It provided participating school districts with $2,200 per building to assess their state of emergency preparedness. As of 2005, about 94% of the public school buildings in the state were participating in the grant initiative. The U.S. Department of Homeland Security had identified Michigan's Homeland Security School Initiative as a national best practice.

School Safety Information Act: 1999 PA 102

In response to school shootings that occurred in the 1990s, the Michigan Legislature passed Act 102 in July 1999—The Michigan School Safety Information Act—which requires local school districts to meet with law enforcement officials to develop emergency plans to handle violent situations. School superintendents are then required to educate local communities about the plans. The plans spell out, among other things, how to evacuate schools, bring first aid and emergency resources to the scene, and handle parents that want to pick up their children. The law also requires the development and implementation of a statewide school safety information policy, the reporting and compiling of certain school safety information, and the expulsion of pupils for certain assaults.

Michigan Office of Safe Schools

In 1998, the Michigan Legislature established the Michigan Office of Safe Schools within the Michigan Department of Education. The Office of Safe Schools began operating in October, 1999. Its mission is to collect and distribute information about school safety. The Office of Safe Schools maintains a web site that serves as a one-stop clearinghouse for information on school safety, school bus safety, food safety, and current and proposed school safety legislation.

In March 2001, the Michigan Office of Safe Schools established a toll-free School Violence Hotline to provide a means for students to anonymously report specific threats of imminent school violence or other suspicious or criminal conduct. The toll-free hotline is operational 24-hours per day, 365 days a year, at 1-800-815-TIPS.

E Team and WebEOC Critical Incident Management Systems

Beginning in 2004, the State of Michigan began to use web-based proprietary software called "E Team" for its emergency management, event management, and homeland security functions, including integration with its

Geographic Information System (GIS) applications in the SEOC. The Emergency Management and Homeland Security Division of the Michigan State Police (EMHSD/MSP) obtained an enterprise license for E Team that allowed it to provide an E Team license to all local emergency management agencies in Michigan. This statewide integration effort allowed state agencies, local emergency management agencies, hospitals and other critical facilities, and certain federal agencies and non-governmental organizations to easily and quickly communicate with the SEOC, and with each other, during disasters or emergencies. During 2012 and 2013, the SEOC will be converting from E Team to WebEOC software.

Midwest Public Safety Communications Consortium

Representatives from the State of Michigan and four other Midwest states have created a consortium that will allow public safety agencies to coordinate radio communications systems across state lines. The Midwest Public Safety Communications Consortium (MPSCC) was formed in 2002 by law enforcement agencies in Illinois, Indiana, Kentucky, Michigan, and Ohio. The goal of the consortium is to create the nation's widest area of interoperable radio communications for police, fire, and emergency medical service departments, stretching from Zanesville in East Central Ohio to the Quad Cities in Illinois and from the Appalachian Mountains in Southern Kentucky to Michigan's Upper Peninsula. Currently, each state is building a unified communications network that allows a variety of public safety agencies to communicate on a single state-of-the-art radio network. This approach will allow agencies near a jurisdictional border to communicate with their peers in neighboring states. This will result in an improved public safety response to combat crime, enhanced coordination of response to traffic collisions, and a more efficient response to major catastrophic events. This effort will also serve to enhance the communications capability of neighboring states in response to a major sabotage/terrorism incident.

Local Governments and Private Industry

Local governments across Michigan, particularly those in southeastern Michigan, are becoming better prepared for sabotage/terrorism incidents. Local law enforcement, fire, public works, emergency medical agencies, and a variety of other local personnel are being trained in how to properly respond to and recover from sabotage/terrorism incidents and threats. In addition, communities are also developing plans and procedures for these incidents, and then testing those plans and procedures in disaster exercises. Local jurisdictions have initiated public information and awareness campaigns aimed at educating businesses and individual citizens of the risks associated with this hazard, as well as steps they can take to adequately protect themselves. Many businesses and critical industries/sectors in Michigan are developing and testing emergency plans and procedures, training personnel in anti-sabotage/terrorism methods, and taking other necessary and prudent actions to protect their critical facilities, infrastructures, and operations from acts of sabotage/terrorism. These combined efforts of government, business and industry, and individual citizens form the cornerstone of Michigan's (and the nation's) continuing fight against sabotage/terrorism.

Michigan Cyber Initiative

The State of Michigan has made numerous advances in its preparedness and security initiatives. The web site at http://www.michigan.gov/cybersecurity provides information to explain numerous aspects of this increasingly important responsibility. It includes Michigan's Cyber Disruption Response Strategy and links to many sources of accurate information about this complex topic.

Hazard Mitigation Alternatives for Terrorism and Similar Criminal Activities

- Using laminated glass and other hazard-resistant, durable construction techniques in public buildings and critical facilities.
- Establishing avenues of reporting (and rewards) for information preventing terrorist incidents and sabotage.
- Consistent use of computer data back-up systems and anti-virus software.

Tie-in with Local Hazard Mitigation Planning

Because many means of implementing mitigation actions occur through local activities, this updated MHMP places additional emphasis on the coordination of State-level planning and initiatives with those taking place at the local level. This takes two forms:

1. The provision of guidance, encouragement, and incentives to local governments by the State, to promote local plan development (including a consideration of drought conditions), and
2. The consideration of information contained in local hazard mitigation plans when developing State plans and mitigation priorities.

Regarding the first type of State-local planning coordination, MSP guidance has included the "Local Hazard Mitigation Planning Workbook" (EMD-PUB 207), which is currently being updated for release by 2015. For the second type of State-local planning coordination, a section later in this plan summarizes hazard priority information as it has been reported in local hazard mitigation plans. Here, it will merely be noted that terrorism was identified as one of the most significant hazards in the local hazard mitigation plans for Cass, St. Clair, and Sanilac Counties.

This is a topic that may not be appropriate for detailed treatment in community hazard mitigation plans, due to the problems of keeping sensitive or confidential information from being misused (and the sometimes politically sensitive nature of local extremist groups or sympathizers), while at the same time obtaining needed input and public approval for your community's plan. This hazard might be included as an appendix that could be separated from the main document when given public scrutiny. Please refer to the text of Michigan's post-9/11 amendments to its Freedom of Information Act (FOIA) for more information to consider in how these changes might affect community planning processes.

Local Vulnerabilities as Determined from Local Plans/Documents

This section provides the most relevant information about specific vulnerabilities identified by local jurisdictions in their hazard mitigation plans or related documents. It may eventually provide a potential method for a preliminary prioritization of statewide risks, although is not yet recommended for this purpose because of differences between the standards for local plans and state purposes. For example, although this state plan includes all hazards, federal review standards only require natural hazards to be assessed. This causes plans to more heavily emphasize natural hazards. In addition, local agencies tend to give highest priority to the protection of human life, while federal hazard mitigation standards are most clearly defined when describing the mitigation of property damage. Nevertheless, this section provides an important source of information that was considered when assessing the extent of risks that are faced by Michigan communities, and that have more severe impacts within some areas and jurisdictions than they do in others.

Please refer to the overview section at the beginning of the hazard analysis section of this plan, for a description of the process used to analyze this information obtained from local plans and assessments.

Please refer as well to the separate section that describes development pressures—this section immediately follows the current one in this plan and is titled "Development Pressures and Trends." Some of the descriptions of local development trends and pressures used in this "Local Vulnerabilities" section will only make full sense to those familiar with the phrases and standards used to identify areas of local development pressure, and those phrases and standards are explained in the next section, even though they also appear here in the local vulnerability summaries. Both these sections of the MHMP are meant to complement each other and supplement the many state and federal sources of information with additional local sources of information and input. In some cases, relevant aspects of both development trends and local vulnerabilities have already been presented in the hazard-specific subsections of this plan (the Hazard Analysis sections that precede this current section).

In this current section of the MHMP, an overview and analysis (along with some tentative prioritizations, where warranted and feasible) is given for each of Michigan's counties for which relevant information about various hazards was available within local plans. As described in the overview section (as part of the "process" description), there were some counties for which information about hazard prioritization was not available in sufficient quality to support this analysis. Nevertheless, attempts have been made in this section to evaluate and compare local vulnerabilities, despite the fact that the effective comparison of risks more properly requires an elaborate method by which different types of impacts and probabilities can be validly estimated and weighed against each other in conjunction with a consideration of mitigation capabilities and established program priorities on multiple levels of government (multiple local levels, state, and federal). Although more of this information has become available in 2014, it is still too soon to have completed and verified such an analysis.

The following text descriptions summarize local plan information that is more jurisdictionally specific than that which was included in the State-level hazard analysis subsections, although care has been taken to expand and refine the hazard analysis so that local emergency management jurisdictions are identified in the description of previous hazard events. All counties that were covered by plans have been considered in this section, in terms of their top hazards and any areas of significant development pressures. The following information focuses upon local hazard aspects that weren't already covered in the state's hazard subsections. All counties are included in the list below, although there are still a few counties that have not completed a local hazard mitigation plan. (More information on this is provided in the "Coordination With Local Hazard Mitigation Planning" section.) Although county and local references have already been included within the hazard-specific subsections of the hazard analysis, this section renders more clearly some of the most significant and interesting information about local hazard priorities, vulnerabilities, mitigation project ideas, and development trends and pressures, as identified in Michigan's local plans themselves.

The information included here emphasizes (within the limits suggested by the sensitivity and confidentiality issues of some of the subjects, and within the limits of summarizing information from thousands of pages of local planning documents in just a few selected pages of the State plan) some key locations, vulnerabilities, assessed risks, and potential losses that have been identified in local plans. Although it is premature on the basis of current information to definitively prioritize all jurisdictions with regard to each other, on each or all known hazards, federal planning requirements insist that a prioritization effort must be made. The information in this section can therefore be taken as representing important enough concerns from the local hazard mitigation plans that it indicates (county) jurisdictions within the state that are perceived at this time to have greater overall or specific vulnerabilities of the sort that could be

appropriate for State assistance and attention to be warranted. Progress over the 2011 plan in this comparative process will take the form of **boldfaced print** to mark locally prioritized hazards that have been confirmed by the state hazard analysis as being especially significant for the jurisdiction. With respect to State hazard mitigation goals and objectives, priority tends to be given to those project applicants whose applications have merits that outweigh other applications in terms of required FEMA criteria (passing a benefit-cost analysis review, consideration of potential environmental impacts, possible effects on endangered species, unique cultural resources such as Native American Burial Grounds, etc.) Rather than prioritizing communities in general, the focus has been upon the selection of projects that are most likely to pass federal criteria for project application review standards. There are very few submitted applications that appear equivalent in merit to other submissions. Variations in the quality and quantity of documentation, the types and effectiveness of proposed mitigation actions, and the extent of alleviated damages, together tend to allow the prioritization of applications during those periods in which they are sought. This basis for prioritizing community grant applications is given a full description within Attachment C in this plan.

Note on Funding, Organizational, and Resource Challenges for Hazard Mitigation Activities

Planning funds have not in the past been prioritized in terms of favoring specific jurisdictions. Funds for the development of hazard mitigation plans have been distributed (or offered) throughout the entire state. One of the few counties that hasn't yet completed its local plan had successfully obtained such funds but then made the decision to withdraw from the grant. Project funds have had a history of being widely and fairly distributed throughout the entire state. Funding is obtainable through the Hazard Mitigation Assistance programs for communities to use in completing or updating their local hazard mitigation plans, and for hazard mitigation projects, once approved plans are in place. Some of this funding is offered annually, but another major source (HMGP) is available only as a result of federal disaster declarations within Michigan. Federal planning requirements now ask for a consideration of how to prioritize communities for the receipt of future funds under hazard mitigation programs. The intention of the State of Michigan is to prefer to continue to provide funds as fairly as possible to communities with a clear need for them, and who have the timely capacity to make use of such funds, which tend to operate within specific time windows and which also tend to have substantial documentation and local match requirements. As shown by the information in Attachment C, this has not tended to favor specific communities over others, because, as will be seen in the following descriptions, all of Michigan's 83 counties have significant vulnerabilities of some kind. The valid prioritization of some communities over others would require an incontestable means of "comparing apples with oranges" and, given the current state of research and methods on this subject, it is best to propose, rather than a standardized and overarching statement of priorities, that prioritization favor areas and vulnerabilities that involve substantial risks to life and property, that have a proven history of occurrence or a significant potential for future occurrence, that the proposed means of hazard mitigation is technically feasible, legally and politically acceptable, capable of meeting FEMA application and review requirements, likely to be implemented by the resources available for marshalling on behalf of the project's accomplishment, and that is consistent with the goals of this Michigan Hazard Mitigation Plan as well as those stated in local hazard mitigation and comprehensive plans. Funding for local hazard mitigation planning activities and projects will ideally remain accessible to all communities throughout the state, although there have been cases where certain types of federal post-disaster funds (i.e. HMGP) have been recommended to address the same type of hazard (e.g. flooding, dam failure) that had made the money available. As the project list in Attachment C documents, however, Michigan's prioritization and selection process has reached every corner of the state, to accomplish hazard mitigation actions for the full variety of hazards that have been chosen by local Michigan communities themselves in response to state notifications of available funding. Although individual communities do vary in what they have received (see the following table), this is not due to the favoring of any particular region or type of jurisdiction, but only on the number, quality, and type of individual grant applications that these jurisdictions' emergency management programs have successfully submitted.

In this 2014 update of the Michigan Hazard Mitigation Plan, information from local plans has allowed the identification of which communities are significantly affected by particular hazards. As local plans continue to be produced and updated, a method of tracking and comparing their information will need to be developed. Local hazard priorities have not changed quickly—most of the updated county plans have reaffirmed the validity of their initial hazard priorities. **One challenge is that the degree of threat from hazards often does not match the degree and type of funds available for hazard mitigation.** Regardless of how hazards vary, the current division of funds by phase of emergency management (e.g. preparedness, mitigation, response, recovery) and by hazard type (natural, such as flooding, versus human-related, such as terrorism) has produced a mismatch that seriously constrains the character of hazard mitigation plans. Communities often identify hazards and vulnerabilities with respect to the amount of

impact they have had, or threaten to have. The result is a wide array of natural, technological, and human-related hazards identified as posing serious risks. But hazard mitigation plans require communities to identify strategies that are specifically considered to be "mitigation" (distinct from preparedness activities which may be just as powerful in protecting lives and property), and a history of federal hazard mitigation funds that clearly emphasizes flooding—one of the most predictable of hazards. The character of hazard mitigation planning itself, treated as completely distinct from other phases of emergency management and only required for natural hazards (some of which are far less controllable than technological ones), tends to shift actual planning actions into a very narrow set of possibilities that have been formally recognized as hazard mitigation that is potentially fundable specifically as such. The result is that hazards, after being identified and prioritized on the basis of their actual impacts and threats, often have to be neglected in favor of lesser threats that have clearer possible actions that can potentially be accomplished, and funded. This makes the hazard analysis that was performed for a hazard mitigation plan potentially more useful for preparedness and response phases of emergency management, since many of the most natural ideas to reduce hazard impacts involve the procurement of and ability to use equipment, or other actions and procedures (such as dredging and maintenance) that have been declared ineligible for federal hazard mitigation funding. Some parts of federal policy has also taken one aspect of hazard mitigation—prevention—and declared it to be a separate new phase of emergency management. New federal requirements which demand the time of state planners, such as the Threat and Hazard Identification and Risk Assessment (THIRA) process, have experimented with new formal procedures without addressing this essential problem of the artificial separation of potential solutions by emergency management phase and hazard type—in which only a very narrow set of the possibilities can actually be pursued under the official definition and funding opportunities for hazard mitigation, proper.

In addition, there is a temporal mismatch between the Michigan Hazard Mitigation Plan update cycle, which is required every three years and seriously challenges the capacity of state planners under this schedule, while local hazard mitigation plans are updated on a five-year schedule. Because of these constraints in resources, conceptualization, and motivation, it has been increasingly challenging to keep improving the quality of hazard mitigation plans on both the local and state levels. Hazard mitigation was originally conceived in terms of flood risks, and only very slowly and laboriously can in expand beyond such a narrow vision to resemble what it should theoretically be—an effort to address all actual and potential sources of harm. State planners who had previously been fully dedicated to promoting, assisting with, reviewing, and processing local hazard mitigation plans have instead needed to devote an increasing amount of their time to new and increasing planning requirements that have become increasingly abstracted and disconnected from the core ideas that local communities have generated in their local plans. Local emergency programs, in placing their highest emphasis upon life safety, tend to naturally gravitate toward activities that inform and warn people about potential hazards, train responders to deal with those hazards, obtain equipment that will enhance the ability of local responders to deal with hazards when they occur, and train the involved agencies in the use of that equipment or the inter-agency coordination that is needed during an emergency. By contrast, federal funding for equipment and preparedness (i.e. previously obtainable through generous homeland security-related sources) has markedly declined. Although this causes increasing interest in hazard mitigation funding sources that are still available, there is also the problem of an increasing recognition of the relative narrowness of hazard mitigation as currently defined by FEMA (which also shapes how lower levels of government must treat the subject). Slow changes can be seen, as with FEMA's recent and very welcome policy which allows the purchase and use of back-up power generators at critical facilities to be a fundable hazard mitigation project (rather than rejected as ineligible because a generator can be called a kind of "equipment"). Similarly, the federal emphasis upon hazard mitigation defined in terms of permanent or long-term solutions has the effect of summarily overlooking short or medium-term activities that might otherwise be effective and cost-beneficial new forms of hazard mitigation (in the fullest sense of that term).

Federal and state government agencies may encourage and promote the inclusion of hazard mitigation considerations within comprehensive community plans, but the actual mechanisms by which such changes take place have been rather slow-moving and extremely difficult to track and verify. Theoretically, some sort of review of local comprehensive plans could occur, to assess at-risk areas and the steps needed or taken to reduce such risks, but in practice, even to locate all existing local plans, let alone to understand their content, effectively places such an activity beyond the scope of all available emergency management (and state planning) staff. Most action steps identified in hazard mitigation plans at any level tend to either be (1) mere recommendations, (2) narrowly defined to meet current federal definitions, or (3) ineligible for federal funding. This reality has limited the amount that this type of plan has been able to accomplish, and also limited the quality of revisions made when updating these plans. Initial enthusiasm for the

concept of hazard mitigation eventually sobers into disillusionment with the limitations and repetitiveness of the project types actually recognized by FEMA for funding, and the difficulty of getting proposals accepted that are not only multi-hazard, but integrate multiple phases of emergency management as well. (These limits appear to be more rooted in regulatory and bureaucratic limits rather than in the staff members themselves; persons can discuss ideas and make changes, but regulations and organizational arrangements are much more intractable.)

Since 2011, nearly two dozen of Michigan's counties have had significant changes in their local plans (plus several communities within other counties). In some cases, a plan that was merely in draft form in 2011 had been fully completed and approved by FEMA. In other cases, an existing plan was successfully updated under the latest federal review standards (although since the major hazards for that county had not changed, major changes were not required in this section to reflect the plan's successful update).

MITIGATION PROJECT FUNDING MADE AVAILABLE IN MICHIGAN SINCE 1994, BY COUNTY (AS OF MAY 2013)

COUNTY	PROJECT TOTAL	FEDERAL SHARE
Alcona	$ 297,992	$ 180,000
Allegan	$ 413,235	$ 308,607
Alpena	$ 566,540	$ 367,088
Antrim	$ 447,511	$ 286,258
Arenac	$ 215,840	$ 127,875
Baraga	$ 78,702	$ 56,255
Barry	$ 332,795	$ 248,413
Bay	$ 3,083,644	$ 2,467,959
Cass	$ 87,520	$ 60,540
Charlevoix	$ 432,579	$ 301,456
Cheboygan	$ 17,876	$ 13,407
Chippewa	$ 566,652	$ 424,989
Crawford	$ 1,967	$ 1,475
Delta	$ 12,575	$ 9,432
Dickinson	$ 84,701	$ 63,297
Eaton	$ 320,086	$ 225,000
Emmet	$ 142,955	$ 56,436
Genesee	$ 4,956,999	$ 3,719,810
Gogebic	$ 609,918	$ 330,089
Grand Traverse	$ 76,989	$ 57,742
Gratiot	$ 405,181	$ 277,352
Houghton	$ 651,742	$ 478,846
Huron	$ 587,630	$ 376,500
Ingham	$ 1,950,331	$ 1,439,293
Ionia	$ 399,372	$ 298,243
Iosco	$ 154,696	$ 67,511
Iron	$ 209,825	$ 148,742
Isabella	$ 58,744	$ 44,059
Jackson	$ 107,637	$ 76,797
Kalamazoo	$ 84,318	$ 63,239
Kent	$ 8,877,038	$ 6,455,211
Keweenaw	$ 150,652	$ 112,500
Lake	$ 27,940	$ 20,000
Lapeer	$ 5,421	$ 4,066
Leelanau	$ 21,975	$ 13,875
Lenawee	$ 147,448	$ 110,586
Livingston	$ 590,470	$ 442,852

Mackinac	$	273,754	$	183,750
Macomb	$	2,374,738	$	1,376,530
Marquette	$	2,130,426	$	1,313,288
Mason	$	27,940	$	20,000
Mecosta	$	109,965	$	109,965
Midland	$	84,056	$	58,637
Monroe	$	1,642,496	$	1,318,570
Muskegon	$	343,898	$	257,923
Newaygo	$	18,638	$	12,000
Oakland	$	3,826,141	$	2,544,356
Ogemaw	$	202,325	$	150,000
Ontonagon	$	64,811	$	48,379
Osceola	$	27,940	$	20,000
Otsego	$	2,106	$	1,575
Ottawa	$	4,303,289	$	3,083,578
Saginaw	$	4,060,032	$	2,664,727
Sanilac	$	615,471	$	375,316
St. Clair	$	356,259	$	267,195
St. Joseph	$	327,175	$	245,381
Tuscola	$	4,010,683	$	2,592,157
Van Buren	$	480,292	$	316,635
Washtenaw	$	536,155	$	402,116
Wayne	$	4,931,743	$	3,633,023
Wexford	$	846,431	$	634,823
Statewide (other)	$	1,246,019	$	827,041
TOTAL in Michigan	$	60,020,279	$	42,192,768

- The totals in this table represent 269 separate project grants. Two-hundred-fifty-six (256) of the projects are complete and the totals included in the table are based actual project costs. For the thirteen (13) grants that were awarded but not yet complete as of May 2013, projected totals were used based on grant application budgets.
- This table includes totals from two multi-county projects that benefitted a total of seven counties. The completed project totals for those two projects were evenly distributed to the counties they benefitted.
- There were a total of twelve projects that yielded benefits that were statewide or regional in nature. Those twelve projects are totaled under the category of "Statewide (other)".
- The project grant totals represented in this table are from grants awarded to the State of Michigan from the Federal Emergency Management Agency (FEMA). The grants were awarded four of FEMA's five separate grant programs that are collectively known as Hazard Mitigation Assistance (HMA). The four grant programs represented in this table are the Hazard Mitigation Grant Program (HMGP), the Flood Mitigation Assistance (FMA) program, the Pre-Disaster Mitigation (PDM) program, and the Repetitive Flood Claims (RFC) program. All grants, other than totaled in the "Statewide (other)" category, were passed through from the State of Michigan to local units of government.

Overview of Significant Local Vulnerabilities, Conditions, and Proposals

The following descriptions of Michigan's counties have had their top-priority hazards **boldfaced** in cases when the Michigan Hazard Analysis has confirmed that these hazards are high-priority not only in comparison with other local hazards, but with other communities around the state as well. This takes another step toward federal requirements that a state plan describe and compare jurisdictions' vulnerabilities, as a potential basis for the prioritization of hazard mitigation projects. The confirmatory process involved a comparison of locally named priorities with the damages reported in the NCDC-derived hazard analysis tables, previous state or federal disaster declarations for that hazard, and the identification of serious historic events involving that hazard. No precise formula has yet been defined for this confirmation and prioritization process, but as a starting point, hazards which accounted for at least $5 million in damages according to NCDC records (counting each associated death as the equivalent of $2 million) would be

designated in boldface for the hazard(s) that had been associated with these criteria. Locally prioritized hazards that have not yet been **bolded** may indeed be quite serious, and are in need of further scrutiny at the state level. In addition, some hazards have been added in **(boldfaced parenthetical)** type, where the state hazard analysis shows evidence (using the same general criteria) that one or more natural hazards might deserve to have their priority elevated in the local plans. (The idea of having an additional confirmatory method was considered, by comparing top county hazards with the areas in which declarations had occurred, but this was considered methodologically impractical, since it is too difficult to connect damage values with specific counties for those events, in the way that NCDC has done, including distinctions between damaged caused by each type of hazards.)

A summary of the NCDC findings (damages/deaths totaling over $5 million in each county, for a particular hazard type) are summarized here, with roughly estimated totals, but it should be noted that nearby counties probably have similar risks which would emerge in a larger sample of events, taken from a longer historical time period (going back before 1996). Therefore, the following list was merely used to confirm local hazard priorities, and to suggest additional ones for prioritization, if they had not already been mentioned as the most significant local hazards. This brief list only covers natural hazards found in NCDC records.

Hail: Kalamazoo ($130M), Kent ($15M), Marquette ($65M), Van Buren ($50M)
Lightning: Wayne (3 deaths)
Ice/Sleet: Macomb ($54M), Oakland ($104M, 1 death), St. Clair ($10M)
Snowstorm: Grand Traverse ($5M crop damage), Leelanau ($13M crop damage)
Severe Winds: Bay ($5M, 1 death), Berrien ($1M, 2 deaths), Calhoun ($29M, 1 death), Clinton ($3M, 2 deaths), Eaton ($5M), Genesee ($10M), Huron ($3M, 1 death), Ingham ($6M), Kalamazoo ($6M, 1 death), Kent ($64M, 3 deaths), Lapeer ($5M), Lenawee ($7M), Macomb ($23M), Monroe ($5M), Montcalm ($16M), Muskegon ($29M, 1 death), Newaygo ($2M, 2 deaths), Oakland ($16M, 2 deaths), Oceana ($5M), Ottawa ($39M, 4 deaths), Saginaw ($8M), Shiawassee ($5M), St. Clair ($7M), Washtenaw ($13M, 1 death), Wayne ($64M, 8 deaths)
Tornadoes: Cass ($6M), Dickinson ($7M), Eaton ($50M), Genesee ($19M, 1 death), Ingham ($21M, 2 deaths), Livingston ($10M), Macomb ($31M), Monroe ($60M), Oakland ($7M, 1 death), Saginaw ($6M), Washtenaw ($13M), Wayne ($91M)
Extreme Heat: Oakland (5 deaths), Wayne (3 deaths)
Extreme Cold: Macomb (3 deaths), Oakland (4 deaths), Wayne (9 deaths)
Flooding: Allegan ($21M, $7M crop damage, 2 deaths), Barry ($13M), Bay ($9M), Berrien ($7M), Branch ($6M), Calhoun ($13M), Cass ($7M), Clinton ($12M), Eaton ($12M), Genesee ($14M), Gogebic ($19M), Gratiot ($10M), Hillsdale ($6M), Huron ($6M), Ingham ($17M), Ionia ($14M), Isabella ($14M), Jackson ($11M), Kalamazoo ($24M), Kent ($11M), Lake ($6M), Lapeer ($16M), Lenawee ($7M), Macomb ($102M), Marquette ($15M), Mason ($7M), Mecosta ($16M), Midland ($9M), Monroe ($10M, 3 deaths), Montcalm ($10M), Muskegon ($13M), Newaygo ($6M), Oceana ($5M), Osceola ($5M), Ottawa ($54M, 2 deaths), Saginaw ($9M), Sanilac ($8M), Shiawassee ($7M), St. Clair ($9M), St. Joseph ($7M), Tuscola ($14M), Van Buren ($11M), Washtenaw ($13M), Wayne ($22M)
Shoreline Hazards: Berrien (15 deaths), Marquette (5 deaths)
Drought: Wayne ($150M crop damage)
Wildfires: Luce ($12M), Marquette ($5M)

Those counties that have updated their plan since the beginning of 2011 have had some additional adjustments made in their descriptive text, which otherwise has been retained from that provided in the 2011 edition of the MHMP.

ALCONA COUNTY – This plan was updated by November 2013 and the update met FEMA requirements. Local adoption of the plan will complete this update process. The wildfire hazard was still identified in their updated local plan as the most significant facing the county. The Alcona plan notes that between 1981 and 1999, 206 significant wildfires occurred in the county The county contains part of the Huron National Forest, which has had over 2,700 fires between 1970 and 1996. Such a large part of the county is forested that a small number of specific areas of wildfire vulnerability would not be appropriate. Wildfire is a hazard that has the potential to affect practically the entire county. The county's local plan has also pinpointed a few selected areas as vulnerable to shoreline and riverine flooding, but the amount of risk there is relatively limited, compared with other counties in the State.

ALGER COUNTY – Weather-related hazards were identified as posing the largest concerns, especially winter weather hazards such as ice and sleet storms, extreme temperatures, snowstorms, and infrastructure failures that can be

associated in many cases with these hazards. This county receives an annual average snowfall of about 200 inches per year, which is also significant in its potential impact on major transportation routes for the Upper Peninsula (Highways 28, 67, 94, and US-41 pass through this county). The county has also suffered some damages from severe winds, with at least 1 death and 2 injuries and $10 million in damages resulting from 27 events between 1950 and 2002. The county notes that waterfront development pressures exist that cause the conversion of natural areas to homes and cottages at a rapid rate, and this State plan determined that Grand Island and Munising Townships met its criteria for significant development pressures. A problem with the break wall at the Grand Marais Harbor was identified, but may have problems being funded under the regulations associated with current hazard mitigation programs.

ALLEGAN COUNTY – Within the county, a plan for the Pokagon Band of Potawatomi was developed and FEMA-approved in July 2012. Allegan has significant **flooding** problems as well as severe weather risks of both the summer and winter variety. The local plan also notes tremendous development pressures (especially at its "four corners") and the classification of 13 jurisdictions in the county as meeting this plan's criteria for significant development pressures agrees with that assessment. The community has a need to reinforce or strengthen dam structures, which probably cannot be met through any existing funding mechanisms of the State or Federal government. Allegan County has 7 dams that have significant downstream developments to protect. The county has also mapped numerous specific areas of flood vulnerability and past damages, for future hazard mitigation consideration.

ALPENA COUNTY – This plan was updated by November 2013 and the update met FEMA requirements. Local adoption of the plan will complete this update process. The updated plan still gives top priority to flooding and dam failure hazards. There are two dams with significant downstream developments that must remain protected. The county also experiences notable winter weather impacts. A specific location of flooding was identified at the Washington Bridge on U.S.-23 where it crosses the Thunder Bay River.

ANTRIM COUNTY – Weather events dominate the local planning concerns of the county, including a 2001 drought event, thunderstorm, wind, hail, and tornado problems, and snow and ice impacts causing hundreds of thousands of damages over recent decades. Specific locations of vulnerability include structures and roadways along Torch Lake, along US-31 through Elk Rapids, the Shanty Creek Resort area (with water and communication towers), and at various shoreline erosion sites.

ARENAC COUNTY – Thunderstorm and wildfire hazards were identified as particularly significant. Numerous damages were reported from past tornado, hail, and wind events. The county also considers itself to have significant development pressures, with a 15.6% population increase between 1990 and 2000 (Michigan as a whole grew by 7% during that time), but only one specific community (Lincoln Township) was identified by the criteria in this State plan as being unusual in this regard, with a growth rate of 57% over that decade.

BARAGA COUNTY – This plan was updated and approved by FEMA in September 2013. The county's most significant hazards were still identified as flooding (both riverine and shoreline), snowstorms, and subsidence. Millions of dollars of damages were caused by three floods between 1994 and 2003, and the county also contains high-risk shoreline erosion areas along Lake Superior. By comparison, impacts from subsidence were considered slight. The local hazard mitigation plan included specific mitigation strategies concerning flooding and erosion. These included the replacement of inadequate culverts along Park Road, Indian Road (by Gomache Creek), and Beaufort Lake (by Spurr River), and eight other locations. Also noted was a project for stabilization of banks along areas of the Sturgeon River to reduce ongoing erosion problems, and which would include the associated reconstruction of nearby Tahtinen and Myllya Roads. These extensive project needs should be assessed locally for their likelihood to meet FEMA-required benefit-cost review and other project funding criteria.

BARRY COUNTY – Top concerns included winter weather and extreme temperatures. The county wishes to expand its warning siren system, and has also made excellent steps toward the coordination of hazard mitigation planning with local comprehensive planning (it has a county planning office that covers a substantial portion of the local land area). This State plan has identified 5 local jurisdictions with significant development pressures. The local plan also refers to addresses with repetitive flood losses but a huge cost that makes an acquisition alternative unfeasible. (**Flooding**)

BAY COUNTY – Their top hazards included **flooding**, winter storms, severe thunderstorms, drought, tornadoes, and wildfires. The county plan lists numerous repetitive-loss properties and describes 21 major flood events since 1947, resulting in more than $100 million in damages. Winter storm damages have resulted in nearly $40 million in damages since 1967. (**Severe winds**)

BENZIE COUNTY – Top hazards included wildfires, winter weather, severe winds, flooding and erosion. The local plan reported 45 winter weather events, 21 wind events, 4 flood events, and a major wildfire affecting 15 acres. The county also has identified high-risk shoreline erosion areas, with structures in 4 locations that would benefit from relocation. The county experiences great seasonal population changes (up to 50% difference at one point in the year).

BERRIEN COUNTY – This plan was updated and approved by FEMA in May 2013. Within the county, a plan for the Pokagon Band of Potawatomi was developed and FEMA-approved in July 2012. The top county hazards still include winter weather, extreme temperatures, tornadoes and **severe winds**, but their newly updated plan has added infrastructure failures and nuclear power plant incidents as high priorities. From 1950 to 2004, 49 significant snow and ice events were documented. Annual average snowfall is 71 inches there. About 5.7 severe wind events occur each year. Several disaster declarations have included a 1975 flooding and tornado event, a 1980 severe wind event, and thunderstorm/wind events. From 1950 to 2002, 27 tornado events were also reported, including 5 particularly notable events that caused 15 injuries, one death, and various property damages. The county proposes the use of generator for various critical local facilities, the replacement of undersized culverts (at numerous specified locations), the relocation of the Berrien Springs Wastewater Treatment Plant, and the removal of 2 dams from along the Paw Paw River. Their plan also notes several proposed developments, including some that are in hazard-prone floodplain areas, and the County includes 8 communities identified in this State plan as being under significant development pressures. (**Flooding** and **shoreline hazards**)

BRANCH COUNTY – High winds, lightning, and winter weather were listed as the most significant hazards. Mitigation actions proposed in the local plan include retrofitting and protective measures for critical facilities, and a drainage project. Many townships don't have zoning ordinances, although the Coldwater area has experienced significant growth recently. (**Flooding**)

CALHOUN COUNTY – Top hazards include **flooding**, thunderstorms, **severe winds** and tornadoes, and severe winter weather. Nine flood events were reported between 1950 and 2005, along with some flash flooding, with about $30 million in resulting damages. Severe weather events caused other injuries and millions more in property damages. The county is fast-growing, with associated development pressures, with the county's comprehensive plan identifying main growth corridors along I-94, in the southern portion of Battle Creek, and along the B-Drive North corridor. The county hazard mitigation plan notes one repetitive loss property. Potentially fundable projects identified in the county's plan include the installation of generators at critical facilities, increasing the area of warning siren coverage, construction of storm shelters, and various acquisition and relocation projects within the City of Albion. The plan also refers to development regulations in Emmett and Newton Townships for a selected area of dam-related risk reduction effect.

CASS COUNTY – The previous draft plan was completed, updated, and then approved by FEMA in January 2012. Within the county, a plan for the Pokagon Band of Potawatomi was also developed and FEMA-approved in July 2012. The county's top hazards still include thunderstorms, terrorism, nuclear attack, nuclear power plant accidents, winter weather hazards, and hazardous materials transportation accidents. The updated and completed plan added infrastructure failures and extreme temperatures as additional high priorities. Mitigation actions proposed by the county include the enhancement and expansion of warning capability and outreach to the area's special populations, consideration of shelter requirements at mobile and modular home parks, improving and maintaining signs and signals at railroad crossings, the use of emergency generators and power supplies for public service departments, and encouraging the development of safe rooms. Potential exists for integrating hazard mitigation considerations into the comprehensive planning process, for their local plan had originated in cooperation between the local emergency management office and the county's planning commission. (**Tornadoes** and **flooding**)

CHARLEVOIX COUNTY – Their top hazards are severe weather, flooding, and wildfires. Winter storm events were twice as common as thunderstorm events, and seasonal population shifts can cause the number of persons in the county to triple. This State plan identified four jurisdictions within the county that met the criteria to identify significant development pressures.

CHEBOYGAN COUNTY – Their top hazard is severe winter weather, including ice, sleet, and snowstorms. It is normal for the county to experience several heavy snow or ice events per year.

CHIPPEWA COUNTY – Their top hazards included severe winter weather and associated infrastructure failures. The plan refers to other local planning mechanisms and the intention to coordinate them with hazard mitigation considerations. Mitigation actions that include locational references involve river warning sensors, snow fences for roads, lightning protection devices, backflow prevention valves, a stormwater detention basin, culvert replacements, facility retrofitting, acquisition of flood-prone properties, insulation of municipal water lines, and construction of safe rooms for critical facilities.

CLARE COUNTY – Severe weather hazards (including hail, lightning, severe winds, and tornadoes) are significant in this county, along with wildfires. Several injuries, plus hundreds of thousands of dollars of damages, have been caused by weather events in the county over the past ten years. In 1977, 1400 acres were burned in a Summerville Township wildfire event. Some flooding has resulted from ice jam conditions in the county. Clare also deals with substantial seasonal population increases (the 1990 census reported 40 to 50 percent of their housing units were seasonal/recreational). Development pressures also exist, with 4 townships identified as having significant pressures according to the criteria used in this State plan. The local plan reports that housing units around lakes have been transforming from seasonal to year-round dwellings in recent years.

CLINTON COUNTY – Top hazards include **flooding**, and ice/sleet storms (with associated power failures). Some coordination with other forms of planning has been evidenced, through a partnership with the Tri-County Regional Planning Commission, a consulting firm, and use of MSU expertise during plan development. Proposed mitigation actions include the identification and acquisition of vulnerable flood-prone properties, and the floodproofing of basements. County planning for land use and capital improvements will reportedly be directed to incorporate hazard mitigation strategies in their updates. (**Severe winds**)

CRAWFORD COUNTY – Top hazards include wildfires and severe winds. In 1990, a wildfire event burned 5,900 acres, including 76 homes and 125 other structures, with property losses of $5.5 million.

DELTA COUNTY – Top hazards included ice/sleet, snowstorms, severe winds, lightning and thunderstorms. Four ice/sleet events were reported between 1994 and 2002, with a January 1994 event being the most severe. Impacts from severe thunderstorms/winds are similar in scope, although spread over many more events. Waterfront development pressures are reportedly converting natural areas to homes and cottages, and recreational dwellings to year-round uses, although these rates were not enough to show up in the measures used to assess significant development pressures in this State plan. Development focuses along a trunkline corridor between Gladstone and Escanaba. The county has listed high-risk erosion parcels in its plan, and its mitigation actions emphasize increased warning notification capacity.

DICKINSON COUNTY – Top hazards included **tornadoes** and earthquakes, the latter being combined with the effects of subsidence related to underground mining. Between 1974 and 2004, nine tornadic events occurred, with property and crop damage that went into the millions of dollars in the area. The county also reported one repetitive flood-loss property in the City of Kingsford. Their mitigation actions included filling or buttressing old mines to prevent collapse, increasing NOAA weather coverage and warning/communication capabilities, use of generators at critical facilities, construction of storm shelters, and addressing the repetitive loss property through elevation or acquisition.

EATON COUNTY – Their top hazards include **flooding** and **tornadoes**. Proposed mitigation actions included dam replacements, identification of repetitively damaged structures, acquisition or relocation of repetitive-loss properties, and expanded identification of urban flood-prone areas. Recommendations are in-place for hazard mitigation considerations to inform comprehensive planning process in the county (which has a county planning office). (**Severe winds**)

EMMET COUNTY – Top hazards include severe winter and summer weather, flooding and erosion. Six major wildfire events in the last few decades each affected between 10 and 44 acres. Three flood events were noted in their local plan, along with the possibility of risk from erosion related both to shorelines and to steep slopes. Significant development pressures exist in parts of the county. Mitigation actions include improvements in shelter capacity and alert notification systems. Consideration of hazard mitigation in comprehensive planning was recommended in the county hazard mitigation plan. Drainage improvements were also proposed.

GENESEE COUNTY – Within the county, a plan for the University of Michigan-Flint was developed and FEMA-approved in December 2012. Top county hazards involved inclement weather (both summer and winter) and associated **severe winds**. The county appears to be more prone to **tornado** occurrences and impacts, including its experience of the most destructive tornado in Michigan history (1953). Other wind, storm, and snow damages have also been very substantial, each going into millions of dollars. City of Flint – "crisis temptation" redevelopment pressures exist – the city had 12% of housing units vacant according to the 2000 census. The county reports 17 repetitive loss properties identified. Participating local jurisdictions in the multi-jurisdictional hazard mitigation plan have agreed to include hazard mitigation considerations in their comprehensive plan update processes. Improvements in warning systems, generators, and shelters were also proposed. (**Flooding**)

GLADWIN COUNTY – Their top hazard was identified as dam failure, with 6 dams located upstream from developed parcels. The county is growing, with new residential developments concentrated around cities, lakes and rivers, and seasonal developments adjacent to the Tittabawassee River. Mitigation strategies emphasize improved warning systems and use of backup generators.

GOGEBIC COUNTY – This plan was updated and approved by FEMA in October 2013. Top hazards still include extreme temperatures, wildfires, and snowstorms, but the new plan has added **flooding**, drought, and oil/gas accidents as high priorities. A 1994 event with record cold temperatures caused frozen pipes that resulted in $2 million estimated damages. An average of more than 3 wildfires occur each year as well as an average of nearly 7 significant snowstorm events. Some examples of the snowfall associated with these storms include 16 inches on January 18, 1996, 23 inches on January 9, 1997, and 10 inches on October 6, 2000. Eighty percent of the county encompasses the Ottawa National Forest, with residential and commercial developments along a corridor between Wakefield and Ironwood. Residential development also occurs alongside numerous lakes, including Lake Superior. The city of Wakefield has produced a flood mitigation plan of its own, requiring improvements with a floodgate at its adjacent Sunday Lake identified problem area. Other county mitigation actions include drainage improvements and underground pipe retrofitting. Provisions for incorporating hazard mitigation into upcoming comprehensive plan updates should be in place.

GRAND TRAVERSE COUNTY – Top hazards include thunderstorms, winds, winter weather (**snowstorms**), flooding, wildfires, ice, and erosion. Since 2004, nearly $100,000 in storm and wind damage has been reported. A January 2004 winter storm dropped 20 inches of snow on the county, resulting in 5 to 6 foot drifts on M-72. Repeated flooding has occurred along the Boardman River, with 7 recorded events including flooding of up to 4 feet depth on Traverse City streets and in basements in 2000. An average of 58 acres are burned per year in wildfire events. Erosion is most notable in Grand Traverse Bay and Peninsula Township (a community with significant development pressures). Mitigation proposals include enhanced warning systems, shelters, removal of unsafe dams on the Boardman River, and improvements to the drainage system in flood-prone areas.

GRATIOT COUNTY – This plan was updated and approved by FEMA in January 2011. Their top hazards still include winter weather hazards, tornadoes, severe winds, major structural fires, thunderstorm hazards, and **flooding**. There is an average of 3.25 significant weather events each year in the counts, and an annual average of 3.1 severe wind events. The county's primary goals are to minimize the harmful effects of severe weather hazards, improve the efficiency of all local emergency responders, and reduce the frequency of utility breakdowns. The county has incorporated hazard mitigation considerations into its master planning process.

HILLSDALE COUNTY – A plan was completed and then approved by FEMA in September 2012. Their top hazards still include energy emergencies, snowstorms, ice storms, tornadoes, structural fires, and wildfires, but in the process of completing the draft (which was all that was available to peruse in the 2011 edition of MHMP), oil/gas well accidents and public health emergencies have also been given high priority. Local development trends focus new developments (of all kinds) around existing cities, villages, selected unincorporated settlements along major roadways, and around ponds and lakes. (**Flooding**)

HOUGHTON COUNTY – This plan was updated and approved by FEMA in October 2013. The top hazard still includes subsidence from large and deep copper mines, but the updated edition of the plan also includes infrastructure failure, terrorism, and structural fires as high priorities. In April 2001, a 3-foot sinkhole appeared near the corner of Red Jackal Road and US-41 in Calumet. The mining inspector reports that numerous ground subsidence events occur each year. Less than half of the county's jurisdictions are zoned, but a consideration of hazard mitigation in future

planning is encouraged in the local hazard mitigation plan. Mitigation actions include bank stabilization along Sturgeon River Road, sewer and storm drainage upgrades for 40 culverts (susceptible to flooding every 3 to 4 years), securing of the Redridge Dam, promotion of mine shaft safety, and the updating of flood maps and stormwater management plans.

HURON COUNTY – Top hazards include severe winter storms, thunderstorms, structural fires, transportation accidents, public health emergencies, and nuclear attack. Between 1950 and 2005, 11 notable tornado events occurred within the county, including an F3 event in 1984 that caused about $2.5 million in property damage. Thunderstorm and winter storm events have caused even more damage (more than ten times as much) during that same time period. New developments tend to occur near existing cities and villages, and along the coastline of Saginaw Bay and Lake Huron, where future condominium developments are anticipated. The incorporation of hazard mitigation considerations into other plans is noted in the county hazard mitigation plan. Mitigation actions include heating and cooling centers, generators for public facilities, expanded warning systems, and burial of power lines. (**Severe winds** and **flooding**)

INGHAM COUNTY – Top hazards include **flooding** and **tornadoes**. Within the county, the plan for the City of Lansing was updated and FEMA-approved in October 2013. In 1975 a severe flood event occurred that inundated 250 homes and businesses. In 2003 and 2007, damaging tornadoes occurred in the county, causing a death, destroyed structures and vehicles. Mitigation actions include the updating of flood maps, relocation or acquisition of repeatedly flood-damaged structures, and encouragement of safe room construction. (**Severe winds**)

IONIA COUNTY – Although their unfinished draft plan did not rank hazards, identified issues included **flooding**, winter weather, thunderstorms, and hail. The Grand River, other rivers and streams, and inland lakes have had floods associated with them. Electrical and phone services have been interrupted by summer storms and associated winds and hail. From 1950 to 2004, 172 significant weather events affected the county, resulting in 3 deaths, 17 injuries, and about $20 million in property damage. Mitigation actions include warning system improvements, strengthening infrastructure against power failures, acquiring portable generators, and removing the Lyons Dam.

IOSCO COUNTY – Top hazards include wildfires and power failures. The majority of new development is along Lake Huron, which may be the most vulnerable portion of the county.

IRON COUNTY – This plan was updated and approved by FEMA in November 2013. Top hazards still include wildfires and dam failures. Between 1981 and 2000, 1,362 acres were burned in the county. There are areas of the county that contain no zoning, but consideration of hazard mitigation is encouraged for future master planning activities. Mitigation actions include promotion of mine shaft safety, the retrofitting of underground pipes, and increased use of NOAA weather radios.

ISABELLA COUNTY – Top hazards include severe weather (both summer and winter) and associated infrastructure failures. Areas of the county have notable development pressures, such as the city Mt. Pleasant and the area around Soaring Eagle Casino. Mitigation actions emphasize the improvement of warning systems. Local communities in the county are encouraged by its hazard mitigation plan to incorporate hazard mitigation into their comprehensive planning activities. (**Flooding**)

JACKSON COUNTY – A plan was completed and then approved by FEMA in December 2011. The top hazards in the county include energy emergencies, public health emergencies, ice storms, snowstorms, structural fires, and tornadoes. The final edition of the plan also identified civil disturbances as an additional high priority. Numerous snow events are documented in their local hazard analysis. Ice and sleet storms were accompanied in most cases by widespread power failures. Structural fires total about $4.4 million in damages per year within the county. Mitigation strategies include the use of back-up generators for critical facilities, the establishment of a community forestry program, and the bolstering of immunization programs for public health. Various communities have significant development pressures within the county. (**Flooding**)

KALAMAZOO COUNTY – This plan was updated and approved by FEMA in January 2013. Top hazards still include severe weather of all types (winter and summer), with documentation of dozens of major weather events between 1950 and 2003, resulting in millions of dollars of damages. The new plan has added **flooding** and tornadoes as additional high priorities. There are numerous areas of strong development pressures within the county, and the

incorporation of hazard mitigation considerations into master planning has been promoted, with multiple local participants agreeing in principle to so in their planning. (**hail** and **severe winds**)

KALKASKA COUNTY – Top hazards include severe weather events (summer and winter), wildfire, and dam failures. Dozens of severe weather events were documented in the county hazard mitigation plan, along with dozens of wildfires. The largest wildfire burned 580 acres, and 22 others burned more than 10 acres each. In the area of the Rapid River, the Rugg Dam and Antrim Pond were noted for hazard analysis considerations. Mitigation actions include the promotion of warning system and weather radio acquisition and use.

KENT COUNTY – This plan was updated and approved by FEMA in June 2012. Top hazards still include winter weather, power failures, and tornadoes, but the new edition also includes **flooding** and thunderstorms (**hail** and **severe winds**) as high priorities. About 100 events were noted in their hazard mitigation plan, in these categories, resulting in millions of dollars of property damage and dozens of injuries and deaths (especially from a 1956 tornado event that destroyed 700 homes). Numerous parts of the county are under strong development pressures. A list of repetitive loss properties was included in the local hazard mitigation plan. Mitigation actions include acquisition of flood-prone properties (especially in Plainfield Township, which is developing its own flood mitigation plan), measures to retrofit existing structures against flooding, an Ada Township acquisition project, improvements to the New York Creek Watershed drainage system, and expansion of warning systems (especially in Grand Rapids).

KEWEENAW COUNTY – This plan was updated and approved by FEMA in October 2013. Top hazards still include winds, shoreline erosion, and snowstorms, with associated power failures (2 per year on average), but the new edition of their plan has also identified infrastructure failures as a high priority. A number of wind and snow events were documented in their local hazard mitigation plan, with associated damages (thousands of dollars). Various high-risk shoreline erosion areas were identified in the plan (no associated flood problems were known). Mitigation projects include the stabilization of Gay-Lac-La Belle Road at 7 locations, a flood mitigation project at Eliza Lake, and promotion of mine shaft safety and NOAA weather radio use. Although this is the least populated county in the State of Michigan, notable residential growth trends are evident.

LAKE COUNTY – Top hazards include winter weather, associated infrastructure failures, wildfires and severe winds. Numerous damaging winter storms were documented during the 1990s, and an April 2003 ice storm event caused massive amounts of property damage and widespread loss of power. Documented wind events have been similarly damaging. Wildfires burned 769 acres between 1981 and 2000, with an average of 8 fires per year and 38.5 acres burned. In 1994, the "county line fire" burned 900 acres of land. The county has various areas of significant development pressures, with residential developments concentrating near the villages of Baldwin and Luther, and around various lakes in the county. The plan notes the presence of two repetitive-loss properties. Mitigation actions include the creation of firebreaks, use of generators, encouragement of hazard mitigation considerations in master planning, and the review of code requirements for mobile home wind resistance. (**Flooding**)

LAPEER COUNTY – Top hazards include snow, ice, hail, lightning, and winds. Many past events were documented in the county hazard mitigation plan, including millions of dollars of damages from various weather events. Most of the county exhibits patterns of significant growth and associated development pressures, including the recent appearance of 10 new mobile home parks. All participating local jurisdictions (27 of them) agreed to consider hazard mitigation concerns within their other planning activities. An estimated 615 structures are located within floodplains. Mitigation actions include the use of generators, enhanced warning systems, storm shelters, and NOAA weather radios.

LEELANAU COUNTY – Top hazards include severe weather of all kinds (winter and summer), Lake Michigan shoreline erosion, and localized **flooding** and dam failure risks. Numerous types of weather events over the last 15 years were documented in the county's local plan. The southern half of the county's coastline is considered a high-risk erosion area. Mitigation actions focus on gathering more detailed information about flood and erosion risk areas, use of warning systems, and snow load design standards. (**Snowstorms** and **Severe winds**)

LENAWEE COUNTY – A plan was completed and then approved by FEMA in June 2012. Top hazards still include extreme temperatures, snowstorms, infrastructure failures, ice and sleet storms, lightning, and hail. Numerous weather events were documented in the county's hazard analysis. Hazard mitigation actions include the development of an outreach program for vulnerable populations during periods of extreme temperatures. Various areas of significant development pressures exist in the county. (**Severe winds** and **flooding**)

LIVINGSTON COUNTY – Top hazards include severe winds and **tornadoes**, with numerous such events documented in the county's hazard mitigation plan. The county is one of the most rapidly growing in the state, with numerous areas of strong development pressures throughout it. The county is very proactive in promoting the inclusion of hazard mitigation considerations within master planning, having identified the potential for development to cause increased risks from flooding. Mitigation actions include the removal of invasive weeds that contribute to the flooding of Ore Lake and the Huron River (in Green Oak and Hamburg Townships), and promoting the acquisition of approximately 25 flood-prone properties in the lowlands surrounding a lake in Green Oak Township.

LUCE COUNTY – Top hazards include **wildfires**, infrastructure failures, winter storms, and thunderstorms. The county is mostly rural, forested land, with various locations of development (of different types) noted in the local hazard mitigation plan. Mitigation actions include infrastructure improvements in the village of Newberry, the installation of natural ("living") snow fences, relocation of a lighthouse at risk from shoreline erosion, and improvements to the county's warning systems. Encouragement is provided for the consideration of hazard mitigation topics in the county master plan. (The county has its own planning office.)

MACKINAC COUNTY – Top hazards include severe summer weather, including thunderstorms, lightning, tornadoes, severe winds, and hail. Numerous historic major weather incidents were documented in the county's hazard mitigation plan, with many thousands of dollars of associated damages. Identified mitigation actions include warning system enhancements, infrastructure reinforcement, snow fences, lightning protection, acquisition of flood-prone properties, and an increased capacity for the water detention basin in the city of St. Ignace. Integration of hazard mitigation into local comprehensive planning is encouraged.

MACOMB COUNTY – This plan was successfully updated on the 5-year schedule established by federal regulations, and a new draft has already been updated in advance of the plan's expiration date. Top hazards are still identified as **tornadoes**, **severe winds**, winter weather (**extreme cold** and **ice/sleet storms**), and **flooding**. Numerous historic occurrences of all these weather events were documented in the county's local hazard mitigation plan, which originally has been an approved plan under the Flood Mitigation Assistance Program and places a great emphasis on flood mitigation. The county is under very strong development pressures – especially in its northern, less-developed half. Mitigation actions include the construction of safe rooms and upgrading of pumping stations, flood mitigation projects addressing dozens of at-risk structures (including repetitive-loss properties), with hundreds of other flood-prone properties identified in the plan. Encouragement of hazard mitigation considerations in comprehensive planning is given in the plan, and although most major projects still require supplementary grant funding in order to be accomplished, the county nevertheless did accomplish a few of its original hazard mitigation objectives, and updated its lists of projects—in some cases with different priorities having been assigned by its participating local communities.

MANISTEE COUNTY – Top hazards include wildfires, winter weather, dam failures, flooding, and coastal erosion. Numerous historic events have been documented in the plan for each of these hazards (except dam failures). Mitigation actions include property acquisitions in flood-prone areas, the protection of sand dunes, and the incorporation of hazard mitigation into local comprehensive plans.

MARQUETTE COUNTY – Top hazards include severe winter weather, public health emergencies, **wildfires**, infrastructure failures, extreme temperatures, violent weather events (**hail**), and **flooding**. Numerous historical hazard events were documented in the county's hazard mitigation plan. This county's local jurisdictions experience significant amounts of both "internal" and "external" development pressures, with a few areas seeing new development while others have lost notable percentages of their residents. Developments in the Chocolay and Carp River drainage basins are increasing the amount and rate of run-off, exacerbating problems for older developments downstream. Hazard mitigation considerations are recommended in local comprehensive planning activities. Flood damages were noted for 475 parcels, with 10 parcels experiencing multiple damages. Mitigation actions include sewer separation in the City of Ishpeming, drainage system developments in Forsythe Township, flood mitigation along the Chocolay and Carp Rivers in Chocolay Township, the elevation of homes along Compeau Creek in Marquette Township, removal of the carp intake dam in Sands Township, elevation of Bayou Road (along with some structures) in Chocolay Township, and the elevation of structures in Republic Township. Originally developed to satisfy both FMAP and HMGP standards, the county's hazard mitigation plan also contains a flood mitigation emphasis within it. (**Shoreline hazards**)

MASON COUNTY – Top hazards include winter weather, extreme temperatures, severe winds, and associated infrastructure failures. Numerous historic events have been documented in the county's hazard mitigation plan for these hazards, which also requests that hazard mitigation considerations be incorporated into local comprehensive plans. Other mitigation actions include increasing the use of NOAA radios, installation of back-up generators at critical facilities, and the use of "living" snow fences. (**Flooding**)

MECOSTA COUNTY – Top hazards appear to include **flooding**, snow, ice, severe winds and tornadoes. Various documentation of past weather events appear in the county's hazard mitigation plan, which suggests mitigation actions including the expansion of warning systems and emergency shelters.

MENOMINEE COUNTY – Top hazards include severe winter weather and extreme temperatures. Various weather events are documented in the county's hazard mitigation plan, which also identified 80 structures within Spalding Township as being at risk for potential flooding. High-risk shoreline erosion areas were also noted along the Green Bay shoreline. Various locations of development areas were noted in the plan, but were not necessarily indicative of exceptional development pressures. Mitigation actions include the use of lightning protection devices, snow fences, NOAA radios and new warning systems, generators at critical facilities and shelters, and improvements in flood maps.

MIDLAND COUNTY – This plan was updated and approved by FEMA in January 2014. Top hazards still include severe winds, winter weather, riverine **flooding**, dam failures, tornadoes, and public health emergencies. Numerous past events were noted in the county's hazard mitigation plan (dam failures do not have an actual history and the presence of development on the Tittabawassee River, downstream from two dams, was noted instead). Most growth occurred in the City of Midland, although another notable area of development was identified along M-20 between Midland and the western county line. Development was considered likely to increase in that area west of Midland and along M-30 north of the Village of Sanford. Mitigation actions include the encouragement of hazard mitigation within local comprehensive plans, the use of river gauges, encouragement of NFIP enrollment, expansion of warning systems and NOAA radio use.

MISSAUKEE COUNTY – Top hazards include severe weather events (summer and winter), and wildfires. The county hazard mitigation plan documented numerous past weather events, plus 14 wildfires that had burned more than 10 acres each. Most of the county is either forest or wetlands, and significant development pressures appear limited to a single township at this time. Mitigation actions include the consideration of new shelters and the inclusion of hazard mitigation considerations within local comprehensive plans.

MONROE COUNTY – Top hazards include severe weather (including winter events, hail, drought, and **tornadoes**). The county's hazard analysis provided documentation of past weather events but did not include hazard mitigation actions. The county planning department is aware of hazard mitigation issues but it is unclear whether these will be incorporated into future updates of local comprehensive plans. The county contains numerous areas with strong development pressures. (**Flooding** and **severe winds**)

MONTCALM COUNTY – Top hazards appear to include tornadoes and **severe winds**, winter storms, **flooding**, and extreme temperatures. The county hazard mitigation plan provided descriptions of numerous past events of these types, and numerous township areas experience significant development pressures within the county. Hazard mitigation actions include the enhancement of warning systems, use of NOAA radios and emergency power generators.

MONTMORENCY COUNTY – Top hazards include severe winter weather and extreme temperatures. Various past events were described in the county hazard mitigation plan, along with associated damages. Mitigation actions include the consideration of hazards within comprehensive plans, the expansion of warning systems in the county, increased use of NOAA radios and backup generators, the placement of snow fences or planting of "living" snow fences, and the study of potential enhancements in sewer and drainage systems.

MUSKEGON COUNTY – Top hazards include winter weather, **severe winds**, and extreme temperatures. Numerous past events were documented in the county's hazard mitigation plan, totaling many millions of dollars of damage over recent decades, including disaster declarations. The existing county plan recommends "smart growth" to direct new developments, and numerous parts of the county are under strong development pressures. Mitigation actions include the consideration of hazard mitigation in comprehensive plans, assessing the capacity of current urban storm sewer systems, use of backup generators at critical facilities, and snow fences along roadways. (**Flooding**)

NEWAYGO COUNTY – Top hazards include winter weather, **severe winds**, and associated power failures. Numerous past events of these types were documented in the county's hazard mitigation plan, along with two repetitive flood-loss properties. Mitigation actions include the incorporation of hazard mitigation considerations into comprehensive planning and zoning, increasing use of NOAA radios, backup generators, and snow fences. (**Flooding**)

OAKLAND COUNTY – This plan was updated and approved by FEMA in January 2013. Within the county, an additional plan for Bloomfield Township was updated and approved by FEMA in October 2011. Top hazards still include flooding and **tornadoes**, but the new edition of the plan also includes winter weather hazards (**ice/sleet storms**, **extreme cold**), transportation accidents (rail), and hazardous materials transportation accidents as high priorities. Numerous past events were documented in the county's hazard mitigation plan, including a major pump station that experiences a harmful failure about once every 20 to 25 years (most recently in November 1998). Huge costs were associated with tornado events, including more than a dozen deaths, 78 injuries, and millions of dollars of property damage as a result of 30 events since 1950. This is the second most populated county in Michigan, and the majority of its communities experience significant development pressures of either the "external" or "internal" type. Land use changes have the potential to exacerbate flooding, and already there are several thousand structures that have identified as at-risk in floodplain locations within the county. Mitigation actions include the installation of new warning sirens, and generators for critical facilities. The consideration of hazard mitigation issues is being incorporated into the municipal plan review process of some jurisdictions, as well as the county's Department of Planning and Economic Development Services. (**Severe winds** and **extreme heat**)

OCEANA COUNTY – Top hazards include winter weather, extreme temperatures, **severe winds**, and associated infrastructure failures. A great number of documented events and their associated damages were described in the county's hazard mitigation plan. Several local jurisdictions experience significant development pressures, and the county mitigation plan included three action items promoting the inclusion of hazard mitigation issues in local comprehensive plans and zoning ordinances. Other mitigation actions include the improvement of warning system coverage and the installation of back-up generators at critical facilities in the county. (**Flooding**)

OGEMAW COUNTY – Top hazards include severe summer and winter weather, and wildfires. Numerous summer and winter storm events were described in the county's hazard mitigation plan, and areas of development were also noted, with mitigation actions emphasizing improvements in warning systems, use of shelters and safe rooms, snow fences, heating centers for vulnerable populations, as well as the protection of electrical infrastructure.

ONTONAGON COUNTY – This plan was updated and approved by FEMA in September 2013. Top hazards still include infrastructure failures, but the new plan additionally identifies hazardous material accidents, terrorism, and oil/gas accidents as top priorities. About two power outages are experienced each year. Mitigation actions include a drainage study for the Village of Ontonagon, dredging of the Ontonagon Harbor, enhancement of mine shaft safety, the construction of a new bridge on M-28, and the relocation of important village offices from the floodplain area in Ontonagon.

OSCEOLA COUNTY – Top hazards appear to include winter weather, tornadoes and severe winds, and **flooding**. Numerous past weather incidents were documented within the county's hazard mitigation plan, along with a map that shows various structures within identified floodplain areas. An associated hazard analysis produced by the county's emergency management office identified thunderstorms, wildfires, winter weather, and tornadoes as the top natural hazards in the county. Mitigation actions include the consideration of hazard mitigation concepts within local comprehensive planning, the provision of firebreaks and improved vehicular access roads for wildfire response, expansion of emergency warning systems, and the increased use of power generators and NOAA radios.

OSCODA COUNTY – This plan was updated in by November of 2013 and the update met FEMA requirements. Local adoption of the plan will complete this update process. Top hazards still include wildfires, severe winds, and winter weather hazards, but the new plan additionally identified infrastructure failures and tornadoes as high priorities. Development patterns have caused increased vulnerability to wildfires, with a 60% increase in rural homes since 1980, and 144 documented wildfires between 1981 and 1999 that affected more than 200 acres each. Some other types of events were also documented in the county's hazard mitigation plan. Approximately 83% of the county's land is forested. Mitigation actions include the increased use of NOAA radios, emergency power generators, sheltering areas at campgrounds and other areas of outdoor congregation, heating centers for vulnerable populations, snow fences, and the encouragement of "Firewise" practices and program participation.

OTSEGO COUNTY – This plan was updated in by November of 2013 and the update met FEMA requirements. Local adoption of the plan will complete this update process. Top hazards still include winter weather, extreme temperatures, and wildfires, but the new plan also identifies transportation accidents and severe winds as high priorities. Various past events of these types were described in the county's hazard mitigation plan. The county's population has tripled since 1960, and several communities are still noted as experiencing significant development pressures – particularly around the City of Gaylord. There is a substantial number of seasonal housing units as well that causes the county's population to swell during certain times of the year. Mitigation actions include the increased use of emergency power generators, warning systems, NOAA radios, heating centers/shelters for vulnerable populations, snow fences, and improvements in the design of water and sewer systems.

OTTAWA COUNTY – This plan was updated and approved by FEMA in May 2012. Top hazards still include severe winter weather, power failures, tornadoes, and **flooding**, but the updated plan also identifies and thunderstorms as a high priority. The county's hazard mitigation plan includes descriptions of numerous past events associated with these hazardous conditions. The county experiences an average of about 97 inches of snowfall per year (due in great measure to the "lake effect" from Lake Michigan). Tornado damages have been extensive, with 20 events between 1956 and 2004. The county, squeezed between three metropolitan areas (Grand Rapids, Muskegon, and Holland), experiences strong development pressures throughout many of its local jurisdictions. A substantial floodplain area has been identified in the county, and one community, Robinson Township, developed its own FEMA-approved flood mitigation plan and associated funding to try to address several areas of its flood-prone structures near the Grand River. Mitigation actions include the acquisition of highly vulnerable flood-prone properties (dozens of vulnerable properties have been identified), the use of building and zoning regulations to limit and protect floodplain developments from harm, a culvert replacement project in the City of Zeeland (at 104th Avenue), expansion of warning systems, increased use of portable generators, and identification of infrastructure vulnerabilities. (**Severe winds**)

PRESQUE ISLE COUNTY – Top hazards include severe winds and infrastructure failures. Various past wind events were identified in the county's hazard mitigation plan. Mitigation actions include improvements to the county's warning system, use of backup power generators and NOAA weather radio, provision of heating centers/shelters, use of snow fences, provision of safe rooms and storm shelters, and infrastructure enhancements (including water and sewer systems).

ROSCOMMON COUNTY – Top hazards include severe weather (summer and winter) and dam failures. A large number of previous weather events were described in the county's hazard mitigation plan, along with identification of one dam that has potentially vulnerable downstream development. Several townships in the county experience significant development pressures, with a large emphasis on tourist and resort attractions. The county contains 17 lakes that are more than 100 acres each, and that attract residential developments. Seasonal/recreational housing accounts for at least 50% of the housing units in the county. Mitigation actions include the use of emergency power generators, expansion of public warning systems, use of snow fences and lightning protection devices, establishment of heating centers and shelters, and improvements in infrastructure.

SAGINAW COUNTY – Top hazards include severe weather (both summer and winter), **tornadoes**, structural fires, hazardous material transportation incidents, **flooding**, and public health emergencies. Heavy detail is provided for the weather and flooding issues. Mitigation proposals include the acquisition of vulnerable parcels, elevation of structures vulnerable to flooding, floodproofing of structures, floodplain mapping, discouraging mobile home parks from occupying floodplain areas, and the consideration of larger-scale flood control measures. Improved warning systems, emergency generators, and aggressive tree trimming were also noted as desirable mitigation actions. (**Severe winds**)

ST. CLAIR COUNTY – Top hazards include hazardous materials incidents (of both the fixed-site and transportation types), infrastructure failures, pipelines, and terrorism, but the county's hazard mitigation plan also identifies 52 properties that have suffered repeated damages from **flooding**. The plan includes an entire chapter that aims to integrate hazard mitigation into policy and regulatory frameworks. Much of the county's eastern coastline consists of planned communities, and most of the county's jurisdictions experience significant development pressures. Mitigation actions include the enhancement of stormwater management standards, use of land use regulations and planning to protect floodplain and coastal zone areas, acquisition or elevation of floodprone properties, increased culvert capacity and use of erosion control structures for the Bunce Creek and Huffman Drain, use of backup power systems at critical

facilities, storm drain improvements, warning system improvements, and provision of storm shelters in selected locations. (**ice/sleet storms** and **severe winds**)

SANILAC COUNTY – Top hazards include wildfires (plus infrastructure failures and terrorism). Wildfires are an annual occurrence in the county. Mitigation actions include the increased use of NOAA radios and warning systems. The county has a couple of townships identified by this plan as experiencing significant development pressures. The local hazard mitigation plan identifies new residential development as concentrating around existing cities, villages, and the lakeshore. (**Flooding**)

SCHOOLCRAFT COUNTY – Top hazards include the winter weather hazards of ice, sleet, and snowstorms. The northern part of the county averages about 120 to 130 inches of snow per year, and the southern part averages about 60 to 70 inches per year. The southern part of the county includes the important transportation route of US-2, whose uses (along with nearly railroad tracks) include the transportation of hazardous materials. (In the northern part of the county are the Michigan highway 28 and another important railroad line that lies nearby.) Two-thirds of the county's population lives within a mile of a trunkline/railroad. Waterfront properties have experienced a trend in which natural areas are being converted into residential and cottage areas. Development along US-2 is expected to intensify, along with the conversion of seasonal homes along lakes and streams into year-round occupancy. Nearly 50% of housing units were reported as seasonal/recreational in the 1990 census. Mitigation actions include expansion of warning systems and NOAA radio use, installment of snow fences, improved use of shelters, increased use of generators, infrastructure enhancements, and the consideration of hazard mitigation issues within comprehensive plans.

SHIAWASSEE COUNTY – Top hazards include snowstorms, **flooding**, and severe weather (thunderstorms, hail, and lightning). The county's local hazard mitigation plan describes numerous snow, flood, and weather events that have affected the county. Major snowfall events have caused up to 15 inches of snow to fall on the county, and during warmer weather, the county experiences an average of 30 to 40 thunderstorms per year. Lightning events alone caused more than $100,000 in property damage during three events from 1998 to 2002 (plus one injury). Infrastructure failures also occur as a result of weather events. Past flood events have included up to 9 feet of basement flooding, backed-up sewers, closed streets (locations are specified in the local plan) and overwhelmed culverts and bridges. Two repetitive loss properties are also referred to in the plan. Mitigation actions include consideration of hazards within comprehensive plans, enhanced warning systems, use of NOAA radios and warming stations, storm shelter provision, flood control, drainage improvements and water storage enhancement, and relocation of a bus barn in Owosso. (**Severe winds**)

ST. JOSEPH COUNTY – No plan or draft plan for the county was on file with MSP/EMHSD, but the emergency management coordinator for the county was contacted specifically so that his input could help to update this section of the MHMP. He related that the top hazards for the county were (in order of priority) tornadoes, thunderstorm hazards, **flooding** and winter weather (about equal in priority), petroleum and natural gas pipeline accidents, and hazardous materials incidents (both fixed-site and transportation-related). The county's flood risk includes a concern with the impacts of dam failure. It was reported that two pipeline incidents had occurred recently.

TUSCOLA COUNTY – Top hazards include severe winds, snowstorms, thunderstorms, hazardous material transportation accidents, ice/sleet storms, and extreme temperatures (cold). Past events of those types are described in the county's hazard mitigation plan. Mitigation actions include enhanced notification methods, the offering of incentives to businesses and residents to modify existing property for hazard resistance, construction of retention ponds and flow constrictors, and flood prevention methods at specifically selected locations. The City of Vassar also has a flood mitigation plan on file (approved under older FMA program standards) and has accomplished many improvements over more than a ten year period, to alleviate the city's flood impacts. (**Flooding**)

VAN BUREN COUNTY – Top hazards include winter weather hazards (**hail**), tornadoes, and associated infrastructure failures. The county hazard mitigation plan includes descriptions of various such events that have occurred in the county, with associated damage estimates. Over 1,200 structures were identified as being within flood-prone areas. A number of areas in the county have experienced significant development pressures. Mitigation actions to address these concerns include the consideration of hazard mitigation within comprehensive plans, increased use of generators and NOAA radios, installation of stormwater relief drains in the City of Hartford, replacement of undersized culverts, flood reduction measures, and use of snow fences. (**Flooding**)

WASHTENAW COUNTY – Within the county, the plan for the City of Ann Arbor was updated and approved by FEMA in September 2012, and a new plan for Eastern Michigan University was developed and FEMA-approved in March 2013. Top hazards include severe weather (**severe winds**, lightning, **tornadoes**, and hail). The county's hazard mitigation plan includes descriptions of numerous significant weather events since 1980. Most of the county feels strong development pressures, and the county plan identifies various development trends. Mitigation actions include the increases in warning sirens, generators, mobile home anchoring, shelters, warming centers, culvert replacement; dam, bridge and spillway repairs; and modification or acquisition of flood-prone structures. (**Flooding**)

WAYNE COUNTY – This plan was updated in by November of 2013 and the update met FEMA requirements. Local adoption of the plan will complete this update process. The new edition of the plan identifies the county's top hazards as severe weather (**lightning**, **severe winds, tornadoes**), infrastructure failures (specifying water systems, electricity, and communications), urban **flooding**, hazardous materials incidents, and public health emergencies. The county plan documents numerous past events for each of these hazards. (There are also multi-hazard plans developed for some jurisdictions within Wayne County, notably the City of Detroit.) Wayne County is the most heavily populated in Michigan, containing about 20% of the State's population, and contains a great number of communities that are under strong development pressures of both the "internal" and "external" variety. Tornado events have had powerfully destructive effects when they strike areas of such density, with damages running into the millions of dollars and injuries numbering in the dozens. Power failures can be particularly harmful to vulnerable residents in heavily urbanized areas of the county where heat effects tend to be exacerbated. Mitigation actions include the establishment of warming and cooling centers, increased use of back-up generators, development of a comprehensive flood mitigation plan and its associated (more specific) flood mitigation actions, use of backflow preventers, stormwater retention and best management practices, and emergency flood relief pumps. (**Drought**, **Extreme heat** and **extreme cold**)

WEXFORD COUNTY – Top hazards include severe winter weather, wildfires, severe winds, and flooding. The county's hazard mitigation plan provides historical background that describes numerous events of these types that have negatively impacted the county. Snowfall events may involve up to 15 inches of snow that causes road blockage, accidents, and power failures. Between 1987 and 2000 15 wildfire events occurred that burned 10 acres or more, including one event that burned more than 50 acres. Strong winds are a frequent cause of power failures, and flood risks have been identified near Lake Cadillac, Silver Creek, the Manistee River, and Fletcher Lake. Mitigation actions include the incorporation of hazard concerns into the county master plan, expanded siren coverage, drainage improvements (including larger culverts), and the provision of storm shelters at campgrounds and trailer/modular home parks.

Development Pressures and Trends

In the 2008 edition of the Michigan Hazard Mitigation Plan, a more extensive consideration of the effects of development trends was begun. The new method that had been created for that update had been found to be useful, and has been retained in subsequent plan updates. It is based upon the preliminary assumptions that there were two general sources of development pressure that could be identified—one rooted in population growth and the other rooted in population decline. The idea is that growth trends may be likely to continue, and can indicate a need to be wary of allowing new developments (or re-developments) to take place in areas that are hazard-prone (the most well-defined such areas usually being floodplains). In the reverse situation—a community that has been experiencing a significant decline in population—the concern is that there might be some slackening of standards that allows more risk-prone development (or re-development) to take place, due to a perceived need by the community to halt its decline. A third circumstance was also identified—communities that are large enough that a significant population shift (either an increase or a decrease) could occur in certain parts of the jurisdiction, even if its overall population had not significantly changed. Municipalities above a certain size are presumed to have some sort of development pressure that they face, and both forms (stemming from growth or decline) may be felt simultaneously in a place that is large enough to have sizeable sections of markedly different character, some of which may experience growth pressures while others experience decline pressures. The 2008 plan had looked at trends using information from the 2000 census, and the 2011 plan was not yet able to make use of new 2010 census information. This new 2014 update has followed through on the intention of the 2011 edition by completing a full reassessment of the list of communities likely to be experiencing development pressures, by making use of new census information.

Although development does not always correspond to population changes, there is a connection between the two, in that population increases can be assumed to correspond with increases in development. Although an area of stable population can also see increases in development (as the wealth that generates that development increases even if the number of residents remains stable), nevertheless this analysis is based on a preliminary categorization that identifies which sections of the state are most rapidly growing (compared to Michigan norms, which, statewide, are of extremely slow population growth – stemming from a pattern in which the rate of natural increase is offset by enduring patterns of net out-migration).

The two types of communities that are assumed to have development pressures are (1) those that have actually experienced significant population growth in recent years (showing both a demand for living there as well as the existence of space or developments that had the capacity to support that population growth), and (2) those that have experienced significant population declines (suggesting that since there had been existing infrastructure and land capable of supporting a larger population, the local community is likely to experience pressures that would encourage it to accept new developments to slow, halt, or reverse its decline). These two types of development pressures might be called external and internal development pressures. In the former case, some demand exists on the part of new residents or potential residents who desire to live in the area, encouraging the community to accommodate such demands by taking action that would satisfy it. In the latter case, the existing infrastructure, land, governmental structure, budgeting considerations, and other factors related to a fear of decline, would be likely to cause the community itself to seek and encourage new developments in contradiction of existing population or market trends. In both these cases, situations can be imagined in which either internal or external development pressures cause certain types of developments to be allowed that may not otherwise have been permitted in the absence of such pressures. In those cases in which decisions might potentially overlook hazard considerations, the long-term impacts can be very substantial, and the very point of hazard mitigation is to determine how current and future hazard vulnerability may be reduced. By considering the impacts of development pressures, and the possibility that some new developments may need to have special design requirements if they will occur in hazard-prone areas, hazard risks and vulnerabilities can be successfully reduced below what they otherwise would have been, as a result of the considerations given to the subjects in (a) this State plan, (b) local planning efforts inspired by, guided by, and coordinated with State hazard mitigation activities and efforts, and (c) local comprehensive (master) plans, to the extent that they have coordinated with local hazard mitigation planning or at least been able to incorporate useful information or consideration of hazards, as suggested either by local hazard mitigation plans or by other documents or activities of local emergency management programs aimed toward accomplishing similar objectives.

Although the definition of what constitutes “significant” growth or decline seemed in 2008 to be a bit arbitrary, the criteria used have been considered sufficiently valid that the resulting classification algorithm has been retained ever since. The following list describes the criteria used to identify communities that experience development pressures:

1. Any community that sees a sufficient percentage increase (5% or more) in its population can be reasonably considered to qualify as a "**significant growth**" community that is subject to "external" (i.e. market demand) development pressures, as long as that percentage equates to at least 500 persons. (In cases of small communities with fewer than 10,000 population, a larger percentage increase of 50% was considered sufficient to denote growth pressures for that community, even if this translates to only a few dozens or hundreds of people).
2. Although some communities may not have increased enough to qualify as having "significant growth" in terms of an increase relative to its overall size, there may exist pockets of significant growth within that community that are subject to rapid development trends or significant development pressures. An absolute increase in population growth that was equivalent to at least a small village (500 persons or more) was considered sufficient to suggest the presence of significant development pressures tied to at least some specific locations within that community, such as a new subdivision, apartment complex, or mobile home park. Although actual specific locations could not be analyzed in this State-level plan, their presence may become part of later analyses and guidance for local planning considerations—as local hazard mitigation plans get updated, and as local comprehensive planning processes become increasingly aware of and informed by the need for hazard mitigation considerations. An absolute increase of at least 500 persons was considered sufficient to denote growth pressures for at least some part of a community, even if this represented only a very small percentage of that community's total population.
3. Any community that sees a sufficient percentage decrease (5% or more) in its population, corresponding to a sufficient absolute decrease (500 persons or more), can be reasonably assumed to be subject to "internal" development pressures of the type that might be called "**crisis temptation**" decisions and outreach, which seeks to attract residents and employers (including riskier industries) through the use of incentives, tax abatements, technical assistance, zoning changes, variances, or unusually permissive attitudes toward any other part of the normal development or redevelopment process. In cases involving small communities (with a population below 10,000), a population decline of at least 30% was considered sufficient to denote substantial redevelopment pressures for that community, even if the absolute number of persons declined by only a few dozen or hundred.
4. Communities of sufficiently **large population** might be considered to have the potential to contain the sort of localized development pressures described in #2 or #3, or both, and therefore the possibility of development pressures should not be automatically ruled out if overall population trends appear flat. Rather, a more detailed analysis (such as a consideration of census tracts or city wards) should be performed by local communities in order to more accurately assess the presence or absence of strong development pressures in that jurisdiction. Although the staff resources to accomplish this are not currently in place at the state level (or are already occupied with higher-priority tasks), a more detailed analysis of census information and photographic images (e.g. Google maps aerial and street views) could allow a more detailed analysis of neighborhood-level development trends. A round figure of 10,000 population (in the 2010 census) was selected as the threshold for classifying a municipality as "large." (Note that a growth or decline of 500 persons is equal to a 5% rate of change for a population of 10,000. The criteria had been chosen to allow them to fit together in this way.)

For this 2014 plan update, census population figures for 2000 were compared with those for 2010. In almost all cases, the names of the municipalities readily matched up and allowed a straightforward comparison. The one exception involved the City of Stambaugh, in Iron County, which was merged into the City of Iron River in the year 2000. In this case, the revised 2000 census total for both cities was compared to the 2010 total for the consolidated City of Iron River.

For communities larger than 10,000 persons, an absolute increase of 500 persons is treated as not necessarily significant in its effect on overall growth pressures for the community, nor necessarily causing specific locations within that community to have unusual development pressures. Due to their already large size, these communities were examined for a 5% population change, rather than the larger 30% or 50% values applied to small communities. Large communities are encouraged to analyze growth trends at a more detailed level than the entire community, to better assess whether development pressures exist, of what type, whether they are concentrated in specific areas, and if so, where these areas exist and whether they are hazard-prone.

These criteria were intended to establish a norm for comparison in the average type of local community in Michigan – a lightly developed, fairly rural or exurban township. All large cities or more heavily populated townships (10,000 population or greater) were considered to be at least potentially exposed to significant development pressures on a localized level within their jurisdictional boundaries, but such potential is best analyzed either in local planning efforts or with use of more detailed information than was made a part of this preliminary analysis. Among small jurisdictions,

the norm is one that has grown less than 500 persons and also less than 50% during the previous decade, but also that has not shrunk by more than 500 persons or by 30% during that same period. Thus, the norm in this analysis was a local community of less than 10,000 population, whose change in population between 1990 and 2000 was between -500 and +500, and greater than -30% but less than +50%. This means that the vast majority of rural townships fell in the "normal" category as not subject to unusual development pressures. A list of population information by county subjurisdictions, for the census years of 2000 and 2010 and including decennial changes both in absolute and percentage terms, was used as the information source for this analysis, and resulted in the list that follows later in this section. **PLEASE NOTE THAT THESE LISTS DO NOT INCLUDE VILLAGES, WHOSE POPULATIONS ARE ALL FAIRLY SMALL AND HAD THEREFORE BEEN INCLUDED WITHIN THE POPULATION FIGURES FOR THE TOWNSHIPS IN WHICH THEY ARE LOCATED.** The lists show which communities are considered likely to be subject to significant development pressures, or to have actually experienced significant growth during the recent period from 2000 to 2010. Each listed community has explanatory information describing the type of development pressures, according to the following key:

LG: Community is listed because its size (10,000 population or more) makes it likely to contain specific locations that are subject to significant development pressures of some kind, although such a condition needs to be verified either through local means or through a more detailed population analysis.

SG: Community is listed because it has experienced significant growth during the period from 1990 to 2000, either in percentage terms (at least 50%) or absolute terms (at least 500 persons), that suggest the likely existence of "external" development pressures on the community or significant locations within it (such locations requiring further analysis to pinpoint). For large communities, a 5% population increase (being at least 500 persons) is considered sufficient to imply the potential for at least one specific location within that community to experience significant development pressures.

CT: Community is listed because it has experience significant levels of population decline during the period from 1990 to 2000, either in percentage terms (at least 30%) or absolute terms (at least 500 persons), that suggest the probability of some sort of "internal" development pressures directed toward the halting or reversal of perceived community decline. For large communities, a 5% population decrease (being at least 500 persons) is considered sufficient to imply the potential for at least one specific location within that community to experience development pressures of the "internal" variety.

N: (not listed) Communities not listed here are not known to have any unusual development pressures. Relevant information to the contrary should be included in local plan development activities, or may be provided to MSP/EMHSD staff for consideration in future updates of this plan.

Some communities in the list have had their entries presented in **boldface** type. This means that they have met all three of the main criteria: (1) they are large communities with more than 10,000 population, (2) they have seen an absolute population change of at least 500 persons during the decade between censuses, and (3) their population changes have amounted to at least 5% of their earlier (2000) population size.

Michigan's 2010 population was officially stated to be 9,883,640, which was 0.6% smaller than the previous 2000 census figure of 9,938,444. This is the first time that the state's population has actually declined.

List of Communities (by county) That Meet the Stated Criteria for Development Pressures
(or potential development pressures at selected locations within their boundaries)

NOTE: The following counties are not included in the list because they contained no communities that met the criteria for unusual development pressures between the 2000 and 2010 census: Alcona, Alger, Antrim, Baraga, Charlevoix, Cheboygan, Clare, Gladwin, Hillsdale, Huron, Iosco, Kalkaska, Lake, Leelanau, Luce, Mackinac, Manistee, Mason, Missaukee, Montmorency, Newaygo, Oceana, Ogemaw, Ontonagon, Osceola, Otsego, Presque Isle, Roscommon, and Sanilac. A large "LG" classification is listed only for communities that do not also have "SG" or "CT" development pressures being noted.

ALLEGAN COUNTY

Community	Reason for listing	Associated population trend
Dorr Township	SG	+860 persons
Leighton Township	SG	+1,282 persons
Otsego Township	SG	+748 persons
Salem Township	SG	+960 persons
Saugatuck Township	SG	+581 persons

ALPENA COUNTY

Community	Reason for listing	Associated population trend
Alpena City	**CT**	**-7%, -828 persons**
Alpena Township	CT	-721 persons

ARENAC COUNTY

Community	Reason for listing	Associated population trend
Standish City	CT	-587 persons

BARRY COUNTY

Community	Reason for listing	Associated population trend
Irving Township	SG	+568 persons
Thornapple Township	SG	+1,199 persons

BAY COUNTY

Community	Reason for listing	Associated population trend
Bangor Township	**CT**	**-6%, -906 persons**
Bay City	**CT**	**-5%, -1,885 persons**
Frankenlust Township	SG	+1,032 persons
Monitor Township	**SG**	**+7%, +698 persons**

BENZIE COUNTY

Community	Reason for listing	Associated population trend
Almira Township	SG	+834 persons

BERRIEN COUNTY

Community	Reason for listing	Associated population trend
Benton Township	**CT**	**-9%, -1,507 persons**
Benton Harbor City	**CT**	**-11%, -1,292 persons**
Chikaming Township	CT	-578 persons
Lincoln Township	**SG**	**+5%, +742 persons**
Niles City	CT	-602 persons
Niles Township	**SG**	**+6%, +839 persons**
Oronoko Township	CT	-650 persons
Royalton Township	SG	+875 persons
St. Joseph Township	LG	population 10,028

BRANCH COUNTY

Community	Reason for listing	Associated population trend
Coldwater City	**SG**	**+5%, +544 persons**

CALHOUN COUNTY

Community	Reason for listing	Associated population trend
Albion City	CT	-528 persons
Battle Creek City	CT	-1,017 persons
Emmett Township	LG	population 11,770

CASS COUNTY

Community	Reason for listing	Associated population trend
Milton Township	SG	+1,232 persons
Ontwa Township	SG	+684 persons

CHIPPEWA COUNTY

Community	Reason for listing	Associated population trend
Kinross Township	CT	-579 persons
Sault Ste. Marie City	LG	population 14,144

CLINTON COUNTY

Community	Reason for listing	Associated population trend
Bath Township	**SG**	**+54%, +4,057 persons**
DeWitt Township	**SG**	**+19%, +2,236 persons**
East Lansing City (pt)	SG	+1,877 persons
Watertown Township	SG	+676 persons

CRAWFORD COUNTY

Community	Reason for listing	Associated population trend
Grayling Township	CT	-658 persons

DELTA COUNTY

Community	Reason for listing	Associated population trend
Escanaba City	CT	-529 persons

DICKINSON COUNTY

Community	Reason for listing	Associated population trend
Iron Mountain City	CT	-542 persons

EATON COUNTY

Community	Reason for listing	Associated population trend
Delta Township	**SG**	**+9%, +2,794 persons**
Windsor Township	CT	-502 persons

EMMET COUNTY

Community	Reason for listing	Associated population trend
Bear Creek Township	SG	+932 persons

GENESEE COUNTY

Community	Reason for listing	Associated population trend
Atlas Township	SG	+736 persons
Burton City	LG	population 29,999
Davison Township	**SG**	**+11%, +1,853 persons**
Fenton City	**SG**	**+11%, +1,164 persons**
Fenton Township	**SG**	**+20%, +2,584 persons**

Flint City	**CT**	**-18%, -22,509 persons**
Flint Township	**CT**	**-5%, -1,724 persons**
Flushing Township	LG	population 10,640
Genesee Township	**CT**	**-11%, -2,535 persons**
Grand Blanc Township	**SG**	**+26%, +7,681 persons**
Linden City	SG	+1,130 persons
Mt. Morris Township	**CT**	**-9%, -2,224 persons**
Mundy Township	**SG**	**+24%, +2,891 persons**
Richfield Township	SG	+560 persons
Swartz Creek City	SG	+656 persons
Thetford Township	CT	-1,228 persons
Vienna Township	LG	population 13,255

GOGEBIC COUNTY

Community	Reason for listing	Associated population trend
Ironwood City	CT	-903 persons
Marenisco Township	SG	+64%, +676 persons

GRAND TRAVERSE COUNTY

Community	Reason for listing	Associated population trend
Blair Township	SG	+1,754 persons
East Bay Township	**SG**	**+8%, +744 persons**
Fife Lake Township	SG	+84%, +1,274 persons
Garfield Township	**SG**	**+17%, +2,415 persons**
Green Lake Township	SG	+775 persons
Long Lake Township	SG	+1,014 persons
Paradise Township	SG	+521 persons
Peninsula Township	SG	+925 persons
Traverse City (pt)	LG	population 14,482

GRATIOT COUNTY

Community	Reason for listing	Associated population trend
St. Louis City	SG	+913 persons

HOUGHTON COUNTY

Community	Reason for listing	Associated population trend
Houghton City	SG	+646 persons

INGHAM COUNTY

Community	Reason for listing	Associated population trend
Delhi Township	**SG**	**+15%, +3,381 persons**
East Lansing City (pt)	LG	population 46,610
Lansing City (part)	CT	-4,918 persons
Mason City	SG	+1,079 persons
Meridian Township	SG	+583 persons

IONIA COUNTY

Community	Reason for listing	Associated population trend
Boston Township	SG	+748 persons
Ionia City	LG	population 11,394
Portland Township	SG	+968 persons

IRON COUNTY

Community	Reason for listing	Associated population trend
Iron River City	CT	-11%

ISABELLA COUNTY

Community	Reason for listing	Associated population trend
Mt. Pleasant City	LG	population 26,016
Union Township	**SG**	**+70%, +5,316 persons**

JACKSON COUNTY

Community	Reason for listing	Associated population trend
Blackman Township	**SG**	**+6%, +1,246 persons**
Grass Lake Township	SG	+1,098 persons
Jackson City	**CT**	**-8%, -2,782 persons**
Leoni Township	LG	population 13,807
Spring Arbor Township	SG	+690 persons
Summit Township	SG	+979 persons

KALAMAZOO COUNTY

Community	Reason for listing	Associated population trend
Comstock Township	**SG**	**+7%, +1,005 persons**
Cooper Township	**SG**	**+16%, +1,360 persons**
Kalamazoo City	CT	-2,883 persons
Kalamazoo Township	LG	population 21,918
Oshtemo Township	**SG**	**+28%, +4,702 persons**
Portage City	SG	+1,395 persons
Richland Township	SG	+1,086 persons
Schoolcraft Township	SG	+954 persons
Texas Township	**SG**	**+35%, +3,778 persons**

KENT COUNTY

Community	Reason for listing	Associated population trend
Ada Township	**SG**	**+33%, +3,260 persons**
Algoma Township	SG	+2,342 persons
Alpine Township	CT	-640 persons
Byron Township	**SG**	**+16%, +2,781 persons**
Caledonia Township	**SG**	**+38%, +3,368 persons**
Cannon Township	**SG**	**+10%, +1,261 persons**
Cascade Township	**SG**	**+13%, +2,027 persons**
Courtland Township	SG	+1,861% persons
East Grand Rapids City	LG	population 10,694
Gaines Township	**SG**	**+25%, +5,034 persons**
Grand Rapids City	**CT**	**-5%, -9,764 persons**
Grand Rapids Township	**SG**	**+19%, +2,604 persons**
Grandville City	CT	-885 persons
Kentwood City	**SG**	**+8%, +3,448 persons**
Lowell Township	SG	+730 persons
Nelson Township	SG	+588 persons
Oakfield Township	SG	+727 persons
Plainfield Township	SG	+757 persons
Rockford City	SG	+1,087 persons
Solon Township	SG	+1,347 persons
Vergennes Township	SG	+578 persons
Walker City	**SG**	**+8%, +1,695 persons**
Wyoming City	SG	+2,744 persons

KEWEENAW COUNTY

Community	Reason for listing	Associated population trend
Eagle Harbor Township	CT	-40%
Houghton Township	CT	-35%

LAPEER COUNTY

Community	Reason for listing	Associated population trend
Almont Township	SG	+542 persons

LENAWEE COUNTY

Community	Reason for listing	Associated population trend
Adrian City	**CT**	**-5%, -1,171 persons**
Madison Township	SG	+1,016 persons
Raisin Township	SG	+1,052 persons

LIVINGSTON COUNTY

Community	Reason for listing	Associated population trend
Brighton City	SG	+714 persons
Brighton Township	LG	population 17,791
Conway Township	SG	+814 persons
Genoa Township	**SG**	**+25%, +3,955 persons**
Green Oak Township	**SG**	**+12%, +1,858 persons**
Hamburg Township	SG	+538 persons
Handy Township	SG	+1,002 persons
Hartland Township	**SG**	**+33%, +3,667 persons**
Howell Township	SG	+1,044 persons
Iosco Township	SG	+762 persons
Marion Township	SG	+3,252 persons
Oceola Township	**SG**	**+43%, +3,574 persons**
Putnam Township	SG	+748 persons
Tyrone Township	**SG**	**+19%, +1,561 persons**

MACOMB COUNTY

Community	Reason for listing	Associated population trend
Bruce Township	SG	+542 persons
Chesterfield Township	**SG**	**+16%, +5,976 persons**
Clinton Township	SG	+1,148 persons
Eastpointe City	CT	-1,635 persons
Fraser City	**CT**	**-5%, -817 persons**
Harrison Township	LG	population 24,587
Lenox Township	**SG**	**+24%, +2,037 persons**
Macomb Township	**SG**	**+58%, +29,102 persons**
Mt. Clemens City	**CT**	**-6%, -998 persons**
New Baltimore City	SG	+63%, +4,687 persons
Richmond City (pt)	SG	+845 persons
Roseville City	CT	-830 persons
Shelby Township	**SG**	**+13%, +8,645 persons**
St. Clair Shores City	**CT**	**-5%, -3,381 persons**
Sterling Heights City	SG	+5,228 persons
Warren City	CT	-4,191 persons
Washington Township	**SG**	**+32%, +6,051 persons**

MARQUETTE COUNTY

Community	Reason for listing	Associated population trend
Forsythe Township	SG	+1,340 persons

Marquette City	**SG**	**+641 persons**
Marquette Township	SG	+602 persons

MECOSTA COUNTY

Community	Reason for listing	Associated population trend
Big Rapids City	LG	population 10,601
Big Rapids Township	SG	+962 persons
Morton Township	SG	+714 persons

MENOMINEE COUNTY

Community	Reason for listing	Associated population trend
Menominee City	CT	-532 persons

MIDLAND COUNTY

Community	Reason for listing	Associated population trend
Larkin Township	SG	+671 persons
Midland City	SG	population 41,706

MONROE COUNTY

Community	Reason for listing	Associated population trend
Bedford Township	**SG**	**+8%, +2,239 persons**
Berlin Township	SG	+2,375 persons
Frenchtown Township	LG	population 20,428
Monroe City	**CT**	**-6%, -1,343 persons**
Monroe Township	**SG**	**+8%, +1,077 persons**
Raisinville Township	SG	+905 persons

MONTCALM COUNTY

Community	Reason for listing	Associated population trend
Eureka Township	SG	+739 persons
Reynolds Township	SG	+1,031 persons

MUSKEGON COUNTY

Community	Reason for listing	Associated population trend
Dalton Township	SG	+1,253 persons
Fruitport Township	**SG**	**+9%, +1,065 persons**
Muskegon City	CT	-1,704 persons
Muskegon Heights City	**CT**	**-10%, -1,193 persons**
Muskegon Township	LG	population 17,840
Norton Shores City	**SG**	**+7%, +1,467 persons**

OAKLAND COUNTY

Community	Reason for listing	Associated population trend
Auburn Hills City	**SG**	**+8%, +1,575 persons**
Berkley City	CT	-561 persons
Birmingham City	SG	+806 persons
Bloomfield Township	CT	-1,875 persons
Brandon Township	LG	population 15,175
Clawson City	**CT**	**-7%, -905 persons**
Commerce Township	**SG**	**+15%, +5,373 persons**
Farmington City	LG	population 10,372
Farmington Hills City	CT	-2,378 persons
Ferndale City	**CT**	**-10%, -2,209 persons**
Groveland Township	CT	-674 persons
Hazel Park City	**CT**	**-13%, -2,541 persons**

Highland Township	LG	population 19,202
Holly Township	**SG**	**+13%, +1,325 persons**
Independence Township	**SG**	**+7%, +2,111 persons**
Lyon Township	**SG**	**+32%, +3,491 persons**
Madison Heights City	CT	-1,407 persons
Milford Township	LG	population 15,736
Novi City	**SG**	**+17%, +7,838 persons**
Oakland Township	**SG**	**+28%, +3,708 persons**
Oak Park City	**CT**	**-10%, -3,076 persons**
Orion Township	**SG**	**+6%, +1,930 persons**
Oxford Township	**SG**	**+28%, +4,519 persons**
Pontiac City	**CT**	**-12%, -8,046 persons**
Rochester City	**SG**	**+22%, +2,272 persons**
Rochester Hills City	SG	+2,142 persons
Royal Oak City	CT	-2,828 persons
Southfield City	**CT**	**-8%, +6,557 persons**
Southfield Township	LG	population 14,547
South Lyon City	**SG**	**+13%, +1,304 persons**
Springfield Township	SG	+595 persons
Troy City	LG	population 80,980
Waterford Township	LG	population 71,707
West Bloomfield Township	LG	population 64,690
White Lake Township	**SG**	**+6%, +1,803 persons**
Wixom Township	LG	population 13,498

OSCODA COUNTY

Community	Reason for listing	Associated population trend
Big Creek Township	CT	-553 persons

OTTAWA COUNTY

Community	Reason for listing	Associated population trend
Allendale Township	**SG**	**+59%, +7,666 persons**
Georgetown Township	**SG**	**+13%, +5,327 persons**
Grand Haven City	**CT**	**-7%, -756 persons**
Grand Haven Township	**SG**	**+14%, +1,900 persons**
Holland City	**CT**	**-7%, -1,811 persons**
Holland Township	**SG**	**+23%, +6,715 persons**
Jamestown Township	SG	+1,972 persons
Park Township	LG	population 17,802
Spring Lake Township	**SG**	**+9%, +1,160 persons**
Tallmadge Township	SG	+694 persons
Zeeland Township	SG	+2,358 persons

SAGINAW COUNTY

Community	Reason for listing	Associated population trend
Bridgeport Township	**CT**	**-10%, -1,195 persons**
Buena Vista Township	CT	-1,640 persons
Kochville Township	SG	+57%, +1,835 persons
Saginaw City	**CT**	**-17%, -10,284 persons**
Saginaw Township	SG	+1,183 persons
Thomas Township	LG	population 11,985
Tittabawassee Township	SG	+2,020 persons

ST. CLAIR COUNTY

Community	Reason for listing	Associated population trend
Algonac City	CT	-523 persons
Casco Township	CT	-642 persons
Clay Township	CT	-738 persons
Columbus Township	CT	-545 persons
Fort Gratiot Township	LG	population 11,108
Ira Township	CT	-1,788 persons
Kimball Township	SG	+730 persons
Port Huron City	**CT**	**-7%, -2,154 persons**
Port Huron Township	**SG**	**+24%, +2,093 persons**

ST. JOSEPH COUNTY

Community	Reason for listing	Associated population trend
Sturgis City	LG	population 10,994

SCHOOLCRAFT COUNTY

Community	Reason for listing	Associated population trend
Seney Township	CT	-34%

SHIAWASSEE COUNTY

Community	Reason for listing	Associated population trend
Owosso City	CT	-519 persons

TUSCOLA COUNTY

Community	Reason for listing	Associated population trend
Indianfields Township	CT	-547 persons

VAN BUREN COUNTY

Community	Reason for listing	Associated population trend
Almena Township	SG	+766 persons
Antwerp Township	**SG**	**+13%, +1,369 persons**
South Haven City	CT	-615 persons

WASHTENAW COUNTY

Community	Reason for listing	Associated population trend
Ann Arbor City	CT	-723 persons
Augusta Township	SG	+1,932 persons
Chelsea City	SG	+529 persons
Dexter Township	SG	+775 persons
Lima Township	SG	+825 persons
Milan City	SG	+701 persons
Pittsfield Township	**SG**	**+16%, +4,696 persons**
Saline City	SG	+770 persons
Saline Township	SG	+598 persons
Scio Township	**SG**	**+28%, +4,394 persons**
Superior Township	**SG**	**+22%, +2,318 persons**
Webster Township	SG	+1,586 persons
York Township	SG	+1,320 persons
Ypsilanti City	**CT**	**-13%, -2,808 persons**
Ypsilanti Township	**SG**	**+9%, +4,186 persons**

WAYNE COUNTY

Community	Reason for listing	Associated population trend
Allen Park City	**CT**	**-1,238 persons**

Brownstown Township	**SG**	**+33%, +7,638 persons**
Canton Township	**SG**	**+18%, +13,807 persons**
Dearborn City	LG	population 98,153
Dearborn Heights City	LG	population 57,774
Detroit City	**CT**	**-25%, -237,493 persons**
Ecorse City	CT	-1,717 persons
Flat Rock City	SG	+1,390 persons
Garden City	**CT**	**-8%, -2,355 persons**
Grosse Ile Township	CT	-523 persons
Grosse Pointe Park City	**CT**	**-7%, -888 persons**
Grosse Pointe Woods City	**CT**	**-6%, -945 persons**
Hamtramck City	CT	-553 persons
Highland Park City	**CT**	**-30%, -4,970 persons**
Huron Township	**SG**	**+16%, +2,142 persons**
Inkster City	**CT**	**-16%, -4,746 persons**
Lincoln Park City	CT	-1,864 persons
Livonia City	CT	-3,603 persons
Melvindale City	LG	population 10,715
Northville Township	**SG**	**+36%, +7,461 persons**
Plymouth Township	LG	population 27,524
Redford Township	**CT**	**-6%, -3,260 persons**
River Rouge City	**CT**	**-2,014 persons**
Riverview City	**CT**	**-6%, -786 persons**
Romulus City	SG	+1,010 persons
Southgate City	LG	population 30,047
Sumpter Township	CT	-2,307 persons
Taylor City	CT	-2,737 persons
Trenton City	CT	-731 persons
Van Buren Township	**SG**	**+22%, +5,262 persons**
Wayne City	**CT**	**-8%, -1,458 persons**
Westland City	CT	-2,508 persons
Woodhaven City	LG	population 12,875
Wyandotte City	**CT**	**-8%, -2,123 persons**

WEXFORD COUNTY

Community	Reason for listing	Associated population trend
Cadillac City	LG	population 10,355

Conclusions

Practically all of the major metropolitan areas in the state can be considered to have developmental pressures stemming either from the "external" market demands associated with the value of land with good access to urban amenities and infrastructure or from the "internal" desire to maintain the status quo in terms of a community's size, resources, budget, services, etc. in the face of potential or actual population declines. This is usually true even for some parts of declining central cities within those metropolitan areas—some parts of Detroit, for example, have been redeveloping even while the population of the city as a whole has kept declining.

It is unclear which types of development pressures are of greater concern in terms of hazard mitigation considerations—although the "external" pressures are probably more widespread in their forms and the number of actors involved, the effects of "internal" pressures would seem instinctively to be nearly as great because the entire point of various policies to prevent "decline" is to create an environment that is equal or more attractive than new "greenfield" locations, and communities that envision themselves to be in a state of "crisis" may be tempted to offer extensive incentives to promote development without necessarily considering the hazard-related risks that may face such developments. There is far more planning literature that deals with the problems of growing communities (the subtopic of "growth management") and the encouragement of redevelopment ("economic development," "infill development," and "neighborhood preservation" subtopics, among others) than there is with the concept of

encouraging a declining area to accept a new, more modest status for its future. This is understandable because of the profit and growth-oriented nature of the American economy and its associated culture.

However, it may make sense for some geographic areas to be "undeveloped" in cases where declining communities can no longer afford the costs of providing and maintaining the previous levels of services that those areas enjoyed when they were thriving. This is something that the City of Detroit has been planning and implementing for several years. In cases where the choice is either to accept fallow areas (or devalued areas with correspondingly lightened zoning classifications) in a declining community or to allow development that under better conditions would not be considered acceptable, it may be better to maintain the old standards, reject questionable forms of redevelopment, and focus on re-organizing a community's budget and focusing its services so as to more effectively operate on the smaller scale that external market forces have encouraged. Although this runs counter to the customary development-oriented thinking for municipalities, given the number of dubious (and even unprofitable) incentives that have been offered in desperation, with debatable results, it makes good sense for shrinking communities to consider a "decline management" orientation that emphasizes good fiscal practices, maintaining a good credit rating, prioritizes services to emphasize the most vital and valuable, and concentrates on maintaining or improving the area's quality of life (improving its environment, schools, maintaining and emphasizing its current and future competitive advantages, converting selected areas of abandonment into historic and tourist attractions related to past glories rather than attempting desperate redevelopment efforts that may further harm an area's image, infrastructure, or declining residential base). A recent book has even been published that focuses upon "Legacy Cities" and includes numerous Michigan examples: "Rebuilding America's Legacy Cities: New Directions for the Industrial Heartland," by Alan Mallach (2012). In the preceding table, communities marked CT or LG are likely to be considering these sorts of dilemmas and tradeoffs (or how to avoid them), which is the main source of "internal" development pressures in communities or their subareas that are facing declines.

At the fringes of most metropolitan areas are communities and more specific locations that are experiencing "external" development pressures and growth trends, due primarily to the patterns associated with metropolitan change (primarily the rise of the automobile and the lessening of the cost of outlying development which often no longer needs services that, historically, could only be provided by cities) that have caused the average family to live in areas that have lower population densities than was true in the past. Although foreign immigration has long been a characteristic of American life that has promoted growth within central cities, the great historic population shifts from American rural areas into those cities, which characterized the first half of the twentieth century, has essentially reversed itself, with many persons now moving or seeking to move back into more rural areas, or at least traditional "suburban-style" areas of only moderate development densities (despite the increasing automotive transportation problems that have been associated with such a trend in recent decades, a problem that has been exacerbated by occupational commuting patterns, increases in the number of second homes, and the number of seasonal resort areas in large areas of the state). Even though it is supposedly more fashionable today to seek an urban residence and lifestyle, this trend may only apply to persons of a particular age, during a specific part of the life-cycle, because the overall population trends in Michigan have not seen much evidence of a substantial shift back to the traditional central cities—just the opposite has occurred even in cities such as Grand Rapids and Ann Arbor, which <u>had</u> seen some recent expansion.

Recent land use trends have seen a continued growth of lesser-density outlying areas at the fringe of metropolitan areas throughout the state, or even in rural areas that have road access considered acceptable for the needs of the select number of residents who decide to and can afford to live so far away from employment centers, hospitals, and various urban conveniences. This is the common pattern with the listed SG communities – most of which are not large cities but small or moderate sized townships and their associated small cities and villages within them. It is true also for metropolitan areas that have many of their older core communities declining in population.

The vast majority of growing communities in Michigan are those that are associated with, but outside the center of larger metropolitan areas. The growth of these communities while older, more central ones decline, is indicative of broader development patterns (and neighborhood cycle and "filtering" effects) that are characteristic of most subsections surrounding any large city in recent decades. (For example, family areas reach a population peak when the resident parents are, on average, in their most active years of childraising, but when children leave home they typically move either to more affordable areas or to other cities for educational or employment purposes, leaving fewer residents per household in the original area which then appears to have experienced a decline, in terms of population, school enrollment, associated retail sales, etc.)

To maximize the effectiveness of efforts to coordinate hazard mitigation efforts with land use planning and future development decisions and regulations, it makes sense to prioritize these efforts in communities that have the largest absolute amount of growth (affecting the largest number of persons) rather than merely those with a high growth percentage. At the same time, it must not be forgotten that there are other forms of development pressures, besides those that actually result in rapid growth, which may cause the approval of projects that are insufficiently hazard-conscious. The likeliest combination of development pressures involves the communities that had been **boldfaced** in the list, which met all three criteria for either growth or decline: being a large community of at least 10,000 persons, and having the greatest population changes both in terms of absolute numbers as well as a percentage of growth/decline. In the table above, these communities would seem the most appropriate to prioritize with regard to their development pressures.

A subsequent level of prioritization that seems to make sense would be to rank the communities' population changes in terms of the absolute number of persons, perhaps prioritizing communities whose change is positive (and thus demonstrating actual growth). In order of absolute population change, therefore, the following large communities are considered to have the most substantial development pressures (communities with a change of less than 2,000 are not included in this prioritized list):

Community	County	Type	Associated population trend	
Detroit City	Wayne	CT	-25%	-237,493 persons
Macomb Township	Macomb	SG	+58%	+29,102 persons
Flint City	Genesee	CT	-18%	-22,509 persons
Canton Township	Wayne	SG	+18%	+13,807 persons
Saginaw City	Saginaw	CT	-17%	-10,284 persons
Grand Rapids City	Kent	CT	-5%	+9,764 persons
Shelby Township	Macomb	SG	+13%	+8,645 persons
Pontiac City	Oakland	CT	-12%	-8,046 persons
Novi City	Oakland	SG	+17%	+7,838 persons
Grand Blanc Township	Genesee	SG	+26%	+7,681 persons
Allendale Township	Ottawa	SG	+59%	+7,666 persons
Brownstown Township	Wayne	SG	+33%	+7,638 persons
Northville Township	Wayne	SG	+36%	+7,461 persons
Holland Township	Ottawa	SG	+23%	+6,715 persons
Southfield City	Oakland	CT	-8%	-6,557 persons
Washington Township	Macomb	SG	+32%	+6,051 persons
Chesterfield Township	Macomb	SG	+16%	+5,976 persons
Commerce Township	Oakland	SG	+15%	+5,373 persons
Georgetown Township	Ottawa	SG	+13%	+5,327 persons
Union Township	Isabella	SG	+70%	+5,316 persons
Van Buren Township	Wayne	SG	+22%	+5,262 persons
Sterling Heights City	Macomb	SG	+4%	+5,228 persons
Gaines Township	Kent	SG	+25%	+5,034 persons
Highland Park City	Wayne	CT	-30%	-4,970 persons
Lansing City (part)	Ingham	CT	-4%	-4,918 persons
Inkster City	Wayne	CT	-16%	-4,746 persons
Oshtemo Township	Kalamazoo	SG	+28%	+4,702 persons
Pittsfield Township	Washtenaw	SG	+16%	+4,696 persons
New Baltimore City	Macomb	SG	+63%	+4,687 persons
Oxford Township	Oakland	SG	+28%	+4,519 persons
Scio Township	Washtenaw	SG	+28%	+4,394 persons
Warren City	Macomb	CT	-3%	-4,191 persons
Ypsilanti Township	Washtenaw	SG	+9%	+4,186 persons
Bath Township	Clinton	SG	+54%	+4,057 persons
Genoa Township	Livingston	SG	+25%	+3,955 persons
Texas Township	Kalamazoo	SG	+35%	+3,778 persons

Oakland Township	Oakland	SG	+28%	+3,708 persons
Hartland Township	Livingston	SG	+33%	+3,667 persons
Livonia City	Wayne	CT	-4%	-3,603 persons
Oceola Township	Livingston	SG	+43%	+3,574 persons
Lyon Township	Oakland	SG	+32%	+3,491 persons
Kentwood City	Kent	SG	+8%	+3,448 persons
Delhi Township	Ingham	SG	+15%	+3,381 persons
St. Clair Shores City	Macomb	CT	-5%	-3,381 persons
Caledonia Township	Kent	SG	+38%	+3,368 persons
Ada Township	Kent	SG	+33%	+3,260 persons
Redford Township	Wayne	CT	-6%	-3,260 persons
Marion Township	Livingston	SG	+48%	+3,252 persons
Oak Park City	Oakland	CT	-10%	-3,076 persons
Mundy Township	Genesee	SG	+24%	+2,891 persons
Kalamazoo City	Kalamazoo	CT	-4%	-2,883 persons
Royal Oak City	Oakland	CT	-5%	-2,828 persons
Ypsilanti City	Washtenaw	CT	-13%	-2,808 persons
Delta Township	Eaton	SG	+9%	+2,794 persons
Jackson City	Jackson	CT	-8%	-2,782 persons
Wyoming City	Kent	SG	+4%	+2,744 persons
Taylor City	Wayne	CT	-4%	-2,737 persons
Grand Rapids Township	Kent	SG	+19%	+2,604 persons
Fenton Township	Genesee	SG	+20%	+2,584 persons
Hazel Park City	Oakland	CT	-13%	-2,541 persons
Genesee Township	Genesee	CT	-11%	-2,535 persons
Westland City	Wayne	CT	-3%	-2,508 persons
Garfield Township	Gd. Traverse	SG	+17%	+2,415 persons
Farmington Hills City	Oakland	CT	-3%	-2,378 persons
Berlin Township	Monroe	SG	+34%	+2,375 persons
Zeeland Township	Ottawa	SG	+31%	+2,358 persons
Garden City	Wayne	CT	-8%	-2,355 persons
Algoma Township	Kent	SG	+31%	+2,342 persons
Superior Township	Washtenaw	SG	+22%	+2,318 persons
Sumpter Township	Wayne	CT	-20%	-2,307 persons
Rochester City	Oakland	SG	+22%	+2,272 persons
Bedford Township	Monroe	SG	+8%	+2,239 persons
DeWitt Township	Clinton	SG	+19%	+2,236 persons
Mt. Morris Township	Genesee	CT	-9%	-2,224 persons
Ferndale City	Oakland	CT	-10%	-2,209 persons
Port Huron City	St. Clair	CT	-7%	-2,154 persons
Huron Township	Wayne	SG	+16%	+2,142 persons
Rochester Hills City	Oakland	SG	+3%	+2,142 persons
Wyandotte City	Wayne	CT	-8%	-2,123 persons
Independence Township	Oakland	SG	+7%	+2,111 persons
Port Huron Township	St. Clair	SG	+24%	+2,093 persons
Lenox Township	Macomb	SG	+24%	+2,037 persons
Cascade Township	Kent	SG	+13%	+2,027 persons
Tittabawassee Township	Saginaw	SG	+26%	+2,020 persons
River Rouge City	Wayne	CT	-20%	-2,014 persons

These are the communities that should seriously consider hazard mitigation concepts in their land use planning and development decisions. For state planning purposes and state-local coordination, the following subsection provides a brief profile of Michigan, its cities and major geographic divisions, and the significance of hazards for them.

BRIEF PROFILE OF THE STATE OF MICHIGAN

Michigan has a land area of 58,216 square miles and a population of about 9.9 million persons. Its 83 counties include numerous urbanized areas, including Metropolitan Detroit. Most Michigan residents live within these urbanized areas, which are mostly located in the southern portion of the State. Michigan is completely covered by local, incorporated government entities—every inch of the State is part of a township, city, or village, and all residents of these minor civil divisions are also residents within one of Michigan's counties. This constitutes a general political and taxation structure for Michigan's many communities, although additional districts overlay these areas as well, such as school districts and congressional districts.

Located in the midst of four of the Great Lakes, Michigan's fundamental geographic feature is its division into Lower and Upper Peninsulas. The Lower Peninsula encompasses approximately 70% of Michigan's total land area, and the Upper Peninsula accounts for the other 30%. The two peninsulas are divided by the Straits of Mackinac, which allow Lake Michigan to drain into Lake Huron. The southern half of the Lower Peninsula has a level to gently rolling surface, with hills rising to elevations between 1,000 and 1,200 feet. The northern half of the Lower Peninsula has higher elevations, with hilly belts of glacial origin reaching elevations of 1,200 to 1,700 feet. The eastern half of the Upper Peninsula is fairly level and often swampy. The western half is higher and more rugged. Michigan has borders on four of the five Great Lakes and has the longest shoreline of any inland state—about 3,200 miles. Michigan also has over 10,000 inland lakes and 36,000 miles of streams.

Michigan has a diversified economy based on agriculture, manufacturing, tourism, services, and professional trades. More automobiles and trucks are produced in Michigan than in any other state. Michigan is the nation's top producer of office furniture, a major source of information technology and software, and a national leader in machine tools, chemicals, and plastics. Michigan is also one of the nation's leading agricultural producers, consistently ranking number one in several product categories.

Michigan has a well-developed, multi-modal transportation system that supports the state's diversified economic activities. The highway system consists of a network of interstate, federal, state, and local routes that connect Michigan communities to major metropolitan areas and economic markets around the country. Michigan has 19 airports that offer commercial passenger jet service to major domestic and international destinations. Freight railroad lines link Detroit and other metropolitan areas with Chicago and other major manufacturing and business centers in the United States and Canada. Michigan also offers 40 Great Lakes ports to facilitate waterborne commerce. Each year, Michigan's transportation system helps move 240 million tons of cargo by truck, rail, air, and ship.

Due to its geography and location, Michigan will always be threatened by natural hazards. The State of Michigan and local governments must always be prepared to manage those types of events when they occur. Due to the frequency of occurrence and the historical vulnerability of the population to those hazards, most communities should probably rate natural hazards as their primary emergency management concern. The principal natural hazard threats to Michigan are tornadoes, floods, thunderstorm winds and lightning, severe winter weather, wildfires, and extreme temperatures.

Michigan's principal technological hazard threats include infrastructure failures, hazardous material incidents, structural fires, major transportation accidents, and petroleum and natural gas pipeline accidents. (It should be noted that many of these threats are a direct or indirect result of the state's position as a major national and international manufacturing and business center. The technological threats present in Michigan are not unlike those present in other industrialized states of similar size and character.)

Michigan's principal human-related hazards include public health emergencies, terrorism and similar criminal activities (including cyber-attacks), and civil disturbances.

State of Michigan Profile Map

Michigan has a diverse population, a diversified economy, and a broad array of physical environments, community types, and living arrangements. A new map of Michigan has been created specifically to explain some of this diversity for readers who need to quickly estimate the potential impacts of a disaster event within some area of the state. It appears on the next page.

Many maps of Michigan (or the United States as a whole) do not include relevant information about neighboring lands, so this brief profile of Michigan will first make mention of the fact that it is adjacent to the states of Ohio, Indiana, and Wisconsin, as well as the Canadian province of Ontario. Michigan's area includes substantial portions of four of the Great Lakes (Superior, Michigan, Huron, and Erie), as well as smaller Lake St. Clair (northeast of Detroit). Despite the prominence of Great Lake shorelines in Michigan's geographic situation, it is extensively connected with its three neighboring states, and with the Canadian province of Ontario. These connections include physical highways, marine ferries and shipping traffic, critical infrastructure (e.g. pipelines, power lines), and communication networks (phone lines, cellular towers, broadcast signals, the internet).

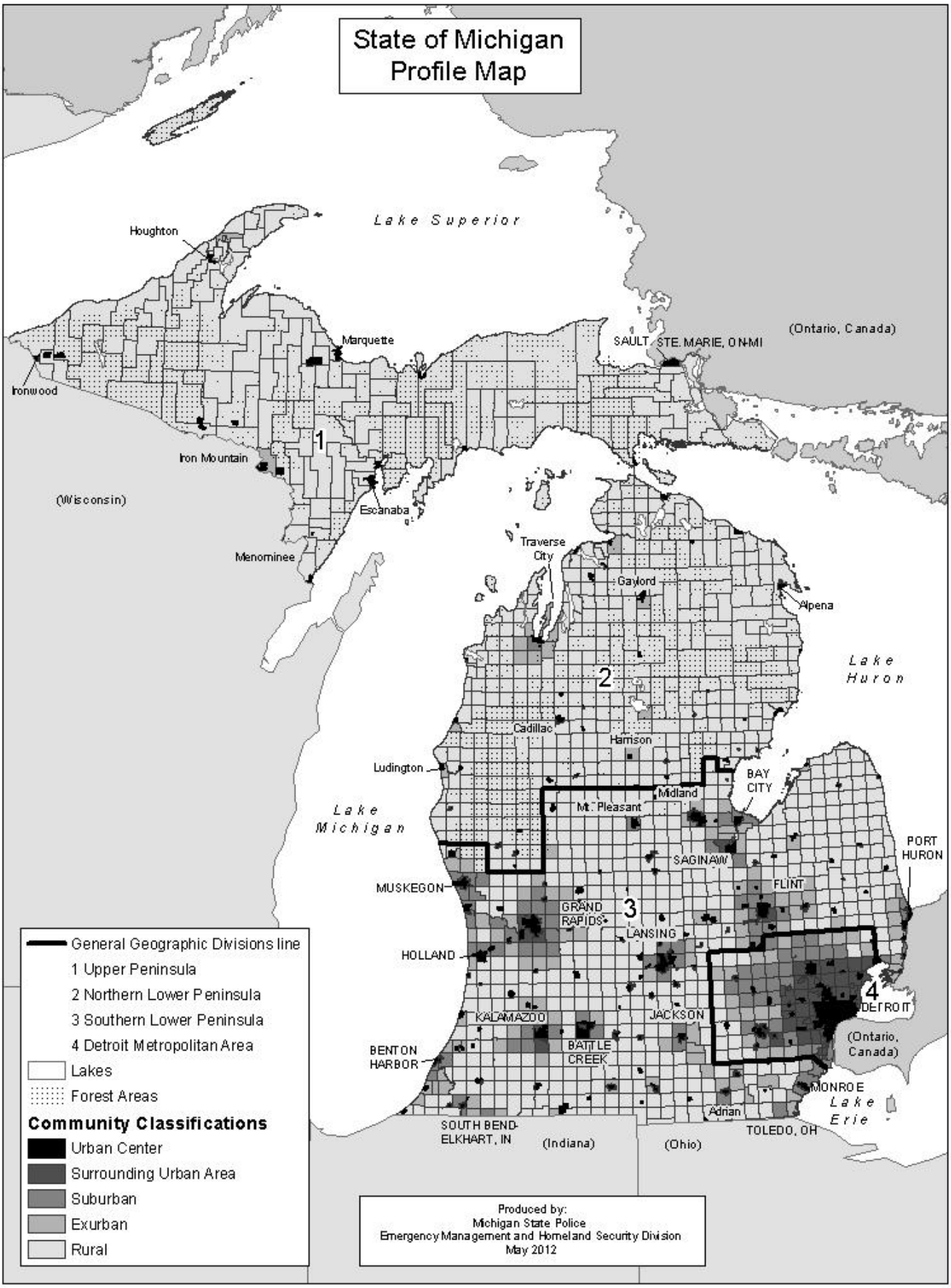
The new Michigan Profile Map presents the State of Michigan in a manner that emphasizes its large number of local governments, and provides basic information about how most of its people, industry, and resources are geographically distributed. The next few pages will provide an explanation of the information shown on this map, with suggestions about how to interpret and use the information in assessing risks at the state and local levels, as well as emergency management concerns and needs.

The Michigan Profile Map is primarily intended for use in emergency management assessments, and an analysis of various kinds of hazards—natural, technological, and human-related. No single map can contain all the information that is relevant for these tasks, so the Michigan Profile Map should merely serve as a starting point, to be supplemented by the many other specialized maps that have been made by Michigan's state government departments (or that are available from other sources).

The Michigan Profile Map was designed to present a selective overview of the general characteristics of Michigan's present settlement, land use, and industrial patterns. Since many of these patterns correspond with differences in climate and vegetation, it was deemed useful to designate four general geographic divisions within the state:

Geographic Division	Number of Counties	Population (2010 census)	Percent of State Total
1. The Upper Peninsula	15	311,361	3.2%
2. Northern Lower Peninsula	29	717,977	7.3%
3. Southern Lower Peninsula	34	4,464,620	45.2%
4. Metropolitan Detroit	5	4,389,682	44.4%
STATE TOTAL	83	9,883,640	

It must be emphasized that these divisions are not meant to correspond with existing planning regions, emergency management districts, Urban Area Security Initiative areas, or census economic areas. The "Community Classification" categories on the map need to be thoroughly explained, in order to fully understand how the map was designed (and how the general geographic divisions were defined). This explanation follows the map on the next page. It is worth noting at the outset that some communities may include areas that better resemble the description for a different category (e.g. a large park may have a rural character within a large central city), and this map doesn't attempt to provide such detail. These classifications are meant only to provide an overview of the State, rather than to precisely indicate local land use patterns.


State of Michigan
Profile Map
Lake Superior
Houghton
Marquette
Ironwood
Iron Mountain
Escanaba
Menominee
(Wisconsin)
SAULT STE. MARIE, ON-MI
(Ontario, Canada)
1
Traverse City
Gaylord
Alpena
Lake Huron
2
Cadillac
Harrison
Ludington
Midland
Mt. Pleasant
BAY CITY
Lake Michigan
SAGINAW
PORT HURON
MUSKEGON
FLINT
GRAND RAPIDS
3
LANSING
HOLLAND
4
DETROIT
KALAMAZOO
JACKSON
(Ontario, Canada)
BENTON HARBOR
BATTLE CREEK
MONROE
Lake Erie
Adrian
SOUTH BEND-ELKHART, IN
(Indiana)
(Ohio)
TOLEDO, OH
General Geographic Divisions line
1 Upper Peninsula
2 Northern Lower Peninsula
3 Southern Lower Peninsula
4 Detroit Metropolitan Area
Lakes
Forest Areas
Community Classifications
Urban Center
Surrounding Urban Area
Suburban
Exurban
Rural
Produced by:
Michigan State Police
Emergency Management and Homeland Security Division
May 2012

Urban Centers

Michigan has many cities located across its lands, from the very small (Omer, population 313) to the very large (Detroit, population 713,777), and many of these date back to the 1800s as official corporate entities. These historical cities appear in black on the map, representing areas that tend to have the greatest densities in population, infrastructure, and the built environment. Only cities have been included in this classification (not villages or townships), but not all cities have been designated as urban centers. Because of the different forms that urban development took in the post-depression, post-WWII period in which automobile accommodations had become the norm, only cities that had incorporated before the end of World War II were included in this category.

Most of these cities contain a traditional downtown area that has long attracted people from outlying areas to engage in commercial or recreational activities, to meet with government representatives, to visit hospitals, or to meet with others in other social, civic, or religious activities. Some of the most historically significant structures in Michigan are located within these cities, and they also contain a vast amount of Michigan's vital government facilities, hospitals, police and military resources, large educational institutions, and major industrial firms. Some of these "urban center" cities contain relatively small downtowns, in cases where they function as "suburbs" near a larger central city, but they have still been classified here as urban centers because their initial formation conformed to a particular style of development that was predominant before World War II. For example, the streets tended to be laid out in the form of a grid, urban designs tended to be focused upon regular access to a thriving central downtown district, and much less accommodation was made for the use of private automobiles by residents.

Dense development patterns and an emphasis upon efficiency characterized most urban center construction projects. Historically, it was to the advantage of most residents and businesses to locate as close as possible to shared transportation and utility resources, and these were designed to accommodate the needs of the persons using them at their time of construction. Many of these designs (for example, combined sewer systems that handle both sanitary and storm drainage functions) are still being changed even today, to accommodate the needs of a larger population that is more productive, enjoys a higher standard of living, and uses more energy to power its higher-technology devices, buildings, and industries. The systems present in these urban centers tend to be the most complex found in the state, and although the capacity to repair most breakdowns in these systems is usually readily available within the larger cities, the complexity and corollary impacts of such breakdowns are also likely to be greater. For example, if a power failure causes traffic signals to fail, this will have a smaller impact upon roadway congestion in a rural area than it would in a central city. Despite the great population density within large urban centers, these communities tend to have a large number of roadways available for use, and the traditional "grid" pattern of street design has long offered a huge number of alternative routes by which people could evacuate an area by car (for short distances).

Surrounding Urban Areas

Since World War II, most of the urban functions that had historically been contained within the urban centers quickly grew beyond the boundaries of those cities. It used to be that the costs of transportation, construction, and urban utilities had required most developments to take place within a city. After World War II, the widespread availability of affordable automobiles, and an increased capacity to affordably build and supply utilities to outlying areas, meant that new projects of all kinds could be built in many possible locations beyond the existing central cities. For many businesses and residents, it still made sense to live near the central city, but many decided not to stay within the political boundaries of the existing cities. A great many new cities incorporated near the older central cities after World War II, typically by converting part or all of an existing township into a city, through a special voting process. Some recent geography texts refer to these areas as "the outer city" (with central cities termed as "the inner city").

Even though some of these new cities (e.g. Southfield) grew to include impressive high-rise office buildings and major expressway interchanges, they still tend to be distinguished from the older urban centers by having a lower average density of population, more widely spaced and modern buildings and infrastructure, and transportation arrangements that are focused upon the predominance of private automobiles. In these locations, it is harder for a resident to choose a residence that allows convenient access to public transit, places of work, hospitals, government offices, and shopping areas unless a car is used to access them. For some types of hazards, the less dense design of these cities is very helpful. For example, contagious illness is much easier to control when people do not need to use public transit systems, and do not live in very crowded residential patterns.

The function of these areas within a broader metropolitan area becomes clearer when looking at the overall land development patterns, as shown on the Michigan Profile Map, rather than focusing only upon the political boundaries between adjacent cities. Whereas large cities in the 19th Century tended to expand through the annexation of adjacent lands, and to contain numerous wards (districts) within them, the 20th Century tended to instead favor urban expansion across a contiguous array of politically (and fiscally) independent cities. On the positive side, this development pattern provided a greater amount of political control by residents over their local governments. On the negative side, certain parts of each urban area tended to become increasingly worse off in fiscal terms, since local taxes were no longer shared throughout an entire urban area. Similarly, various types of infrastructure and services sometimes became increasingly difficult to coordinate across municipal boundaries, and the functions and services provided by urban centers were sometimes not adequately compensated for by users who lived outside of the providing city. Neighboring cities would often spend money on redundant services and facilities, rather than pooling their funds together into combined systems that could benefit from an economy of scale. However, from an emergency management perspective, these redundancies of services and infrastructure could sometimes result in increased local resilience—the seeming inefficiencies of duplicate systems and services could sometimes pay off when an infrastructure breakdown in one city could be offset by the continued functioning of the infrastructure in an adjacent city.

Any city known to have incorporated after World War II has been included in the "surrounding urban area" category instead of being classified as part of an urban center. However, some heavily populated townships have also been classified in this category, as urban. (No effort has been made in these classifications to try to preserve the often contradictory and overly simplistic ideas that many persons still have about the concept of a "suburb"—there is often little practical difference in the character of communities that did or did not vote to officially become cities.) Any Michigan township with a population density of at least 1400 persons per square mile of land area has been classified within this category, as "urban." These communities (whether townships or cities) often may not contain traditional downtown districts, but frequently do have specialized areas for shopping (shopping malls), conducting business (office complexes), and manufacturing products (industrial parks). Although these highly separated land uses may seem inconvenient from the perspective of transportation access, economic efficiency, and design regulations, there are often emergency management benefits realized from this design, in that a disaster in one location (e.g. an industrial explosion or hazardous materials spill) might not affect any of the other locations (or types of activities associated with them).

In terms of evacuation potential, most of these cities have very few local roads that were laid out in the traditional "grid" pattern, but there still tend to be a limited number of alternative routes available. Many neighborhoods might seem maze-like at first, but may allow traffic to eventually wind its way to the other side. Many of these cities (and urban townships) do have a moderate number of "collector" roads that can provide some congestion relief for traffic.

Suburban Areas

In this classification system, a suburb indicates only a township of moderate development and population density, located near an urban center. No cities are included in this classification. Townships with a population density between 277 and 1399 persons per square mile of land area have generally been given this classification as "suburban."

Many of these suburban areas are charter townships, and the main distinctions between a charter township and a city involve a cap on the township's tax rate, a charter township's acceptance of a pre-defined charter, and a self-imposed set of restrictions upon the types and densities of land uses permitted in the township. Although some of these land use restrictions might seem at first to be artificial and arbitrary to an observer, in most cases the restrictions are roughly in accordance with the level of development that one would ordinarily expect to occur in the outlying and newest districts of a city, anyway. Thus, although one tends not to see a skyscraper in the midst of a low-density residential neighborhood, there are many cases in which new factories or warehousing operations are built on the outskirts, especially along rivers or railroad tracks that may be vital to these facilities. Indeed, one of the main trends of the 20th Century that continues to this day is the increased economic feasibility of building many types of projects in outlying locations, and some suburban areas contain important industrial, office, shopping, and recreational facilities.

For emergency management purposes, the main distinction between the previous "urban" classification and the "suburban" one is that a lesser density of development will be typical in the suburban areas. A disaster in a suburban area will tend to affect fewer people than a comparable disaster within an urban area. However, due to the limited

revenue streams for developing the suburban area's infrastructure, suburban areas tend to be more vulnerable to transportation back-ups, to the point of making some areas excessively difficult to evacuate quickly. Few, if any, suburban neighborhood streets are laid out in "grid" fashion, and many neighborhoods may not provide any way for vehicles to cross through them to main roads on their other side. Expressway ramps and bridges over rivers might be far too few in number and capacity, leading to excessive traffic backups on area expressway routes (and the few main streets that connect with it), if one of those ramps or bridges becomes unusable. The community's main (arterial) roads are often just slightly revamped versions of the original "country roads" that existed before all the new suburban growth. Often, the addition of occasional turn lanes have been the only upgrades that have taken place during the community's recent decades of development, and these two-lane roads would quickly become clogged with traffic when an accident occurs or an evacuation is attempted.

SPECIAL NOTE: Every inch of Michigan's land area is not only considered to be a part of one of Michigan's 83 counties, but is also considered to be part of a "minor civil division" (a city, village, or township). The United States census tends to treat villages more like special taxation areas within townships, rather than as small cities, but Michigan also has a great number of small communities that are neither villages nor cities. In this document, these communities will be called "towns," with the understanding that this word has a distinctive meaning to refer to the communities located within Michigan's townships. The Michigan Profile Map shows the boundaries of all of these many townships, but does not show all the small villages and "towns." Most rural areas include such "towns," and although some are mere hamlets, barely distinguished from the rural areas around them, others may be quite sizeable. Such "towns" tend to include either their own post office or school district, and thus may be called by a completely different name than the surrounding township (or may cross over the borders of adjacent townships).

Exurban Areas

The term "exurb" refers to a fairly low-density township whose residents commute regularly to a larger area for many or most of their needs. Suburbs tend to provide a moderate number of urban amenities, including employment, to their residents, but exurbs tend merely to provide residential housing areas and a few minimal services and provisions. In many cases, basic groceries are obtained from a traditional village, "town," or small city that had existed before a commuter population had moved into the area. Exurbs do not contain enough employment opportunities for the residents who live there, and so in addition to residents who choose to commute long distances to work (or who are able to "telecommute"), exurbs may also be home to a large proportion of retirees. Exurbs are generally low in population and development density (except for the central villages or small urban centers that tend to serve them). Various services (including health care) tend to be very limited in these areas.

Townships with a population density between 139 and 276 persons per square mile of land area have generally been classified as exurbs. Some exceptions were granted, such as Breitung Township (near Iron Mountain), in which part of the very large township (67.7 square miles of land area) functioned as a suburb, while another part was quite rural. Another exception was made for the City of Mackinac Island, since its overall population density was rural (it has one of the smallest populations among Michigan cities) and it is generally only accessible by ferry or airplane. Although most suburbs exist on the farthest fringes of urban areas, a few additional types of areas also received this classification, such as communities that are not connected with cities, used for resorts, retirement living, or seasonal homes. An example is Houghton Lake, in Roscommon County, which has a "town" around the lake's shores, but is not actually a city. Some communities were designated as exurbs merely because its center was a "town" or village rather than a city. The United States census tends to treat villages as a special taxation zone within a township, and the Michigan Profile Map was predominantly based upon census data.

Rural Areas

Most of Michigan has been classified as "rural" on the Michigan Profile Map. This does not in any way indicate that these areas are unimportant! In addition, it must be noted that a great number of villages and "towns" exist throughout these rural areas, but are not marked on the map, due to their comparatively small sizes. (Please review the SPECIAL NOTE on the previous page, for more information about the meaning of "town" in this document.)

Some of Michigan's most productive, famous, and important industries are found throughout its rural areas. For example, extraction industries have been quite important to Michigan, whether the mining that had once caused the Western Upper Peninsula to thrive, or the petroleum and natural gas deposits that are increasingly in demand worldwide, or even just Michigan's abundant supplies of fresh water. Logging, farming, the cattle industry, and

facilities for renewable energy (e.g. wind farms or hydroelectric dams) are other important facilities and infrastructure that exist in Michigan's rural areas. Due to the limitations inherent in the use of only a single statewide map, these types of production were not represented graphically. However, more information is presented later in this document, as well as in the passages that follow, describing Michigan's general geographic divisions.

With this in mind, the following paragraphs provide general descriptions of each area's characteristics that were considered to be most relevant for an analysis of risks and hazard impacts. Where information is provided about population centers, the 2010 census has been the source of information used. The "urban areas" designated by the U.S. Census have tended to be presented here as the most relevant means of conveying information about most of Michigan's populated areas, since they are defined in terms of actual land use rather than mere political boundaries. Some of the official urban areas have already been classified as part of a larger metropolitan area (e.g. Ann Arbor), and that status will be clarified in the descriptions that follow (along with alternative ways of conceptualizing and classifying these areas).

1. The Upper Peninsula

As shown on the Michigan Profile Map, most of the Upper Peninsula is covered with forest lands, and most inhabitants live in small cities, villages, and towns in the midst of these forests. These communities are often very old. The Upper Peninsula used to have a huge timber and mining industry, during the 19th Century, and had lost most of its population during the 20th Century after these industries had declined in size. (In 1910, Calumet-Laurium used to be one of Michigan's most populous communities—Houghton County had a population of 88,008 and Calumet Township's population of 32,845 was comparable to that of Jackson, Kalamazoo, or Lansing at the time, but today the township only has 6,489 residents.) The Upper Peninsula's historic mining industry makes certain portions of it more vulnerable than the rest of the State to a ground subsidence hazard.

The Upper Peninsula is predominantly rural, and every one of its counties has a population density that is well below the State's average. Because the area developed during the 1800s, most of its cities have areas that are very old and date from that time period. The Upper Peninsula is adjacent to Wisconsin and Ontario, Canada, and some cities are part of urban areas that cross over state (and national) borders. These cross-border urban areas include Sault Ste. Marie (Ontario and Michigan), Iron Mountain-Kingsford (Michigan and Wisconsin), and Marinette-Menominee (Wisconsin and Michigan).

Taking into account the broader metropolitan areas, then, the city of Sault Ste. Marie might be considered the most significant for the Upper Peninsula. Although the Michigan portion of this area has only about 14,000 people, the much larger Canadian city of Sault Ste. Marie dominates an urban area of nearly 100,000 total population. All marine traffic going from Lake Huron to Lake Superior passes through the Soo Locks, in this area. This includes marine traffic traveling to and from major ports such as Duluth (Minnesota) and Thunder Bay (Ontario, Canada). The only Interstate Highway in the Upper Peninsula (I-75) goes through this city and crosses the International Bridge into Canada. The Mackinac Bridge is another vital element of Michigan's infrastructure, providing a highway connection between Michigan's Upper Peninsula and its Lower Peninsula. Several high-quality surface highways cross the Upper Peninsula and provide the main routes for its truck traffic. Along with freight trains, these highways pass through large areas of State and National Forest Lands, which means that wildfires are one of the most significant threats in the area.

The Upper Peninsula's urban areas, ranked by population size according to the 2010 U.S. census, are:

(Sault Ste. Marie Ontario-MI)	92,914 (2011 Canadian statistics plus 2010 U.S. census)
Marquette	26,946
Escanaba	20,850
(Marinette-Menominee, WI-MI)	19,431
Iron Mountain-Kingsford	19,228
Houghton	15,452
Sault Ste. Marie (Michigan part only)	14,144 (within the city, rather than in the defined Urban Area)
Ishpeming-Negaunee	12,301 (in Marquette County)
Laurium-Calumet	7,325 (in Houghton County)
Ironwood	7,134 (in Gogebic County)
Kinross	6,555 (in Chippewa County)

Manistique	3,482	(in Manistique County)
Newberry	3,225	(in Luce County)
Iron River	3,208	(in Iron County)
Munising	2,972	(Alger County)
St. Ignace	2,531	(Mackinac County)

The Upper Peninsula has a much larger forestry sector than the other parts of the state. Its percentages employed in the construction, manufacturing, and retail trade sectors are significantly larger than for Michigan as a whole. This is also true for the "accommodation and food services" sector of the economy.

2. The Northern Lower Peninsula

This area is predominantly rural in nature, and (as shown on the Michigan Profile Map) is widely covered with forest lands, but includes significant resort and tourist areas, and profitable groves of fruit-growing trees. It is a popular area for hunters, and has a large proportion of its housing units dedicated to seasonal and recreational uses (e.g. hunting lodges, summer cabins). Large state and national forest areas are located in this part of the state, as indicated on the Michigan Profile Map. Many small cities, villages, and towns are located throughout the area's 29 counties. A generally good system of surface highways connects the area. Trains are limited to freight uses, rather than passenger travel. A few airports and passenger ferries are in operation within the area, and there are some excellent ports for handling marine traffic.

The urban areas in the Northern Lower Peninsula, ranked by population according to the 2010 U.S. census, are:

Traverse City	47,109	
Alpena	14,258	
Cadillac	11,690	
Ludington	10,710	(in Mason County)
Manistee	9,606	(in Manistee County)
Houghton Lake	8,300	(in Roscommon County)
Gaylord	8,298	(in Otsego County)
Petoskey	8,210	(in Emmet County)
Au Sable-Oscoda	6,384	(in Iosco County)
Clare	5,597	(in Clare County)
Cheboygan	4,517	(in Cheboygan County)
Fremont	4,496	(in Newaygo County)
East Tawas	4,372	(in Iosco County)
Charlevoix	4,179	(in Charlevoix County)
Grayling	3,858	(in Crawford County)
Harrison	3,589	(in Clare County)
Boyne City	3,501	(in Charlevoix County)
Newaygo	3,335	(in Newaygo County)
Gladwin	2,934	(in Gladwin County)
Kalkaska	2,668	(in Kalkaska County)
Rogers City	2,560	(in Presque Isle County)
Hart	2,556	(in Oceana County)

The Northern Lower Peninsula has larger forestry, fishing, and hunting sectors than most other parts of the state, as well as the majority of Michigan's employment in extractive industries (oil, gas, mining, and quarrying). The area's percentages employed in the construction, retail trade, and the health care and social assistance sectors are significantly larger than for Michigan as a whole. This is also true for the "accommodation and food services" sector of the economy.

3. The Southern Lower Peninsula (excluding Metro Detroit)

This area contains many medium-sized urban areas and most of Michigan's traditional farming and livestock grazing lands. It is adjacent to the States of Indiana and Ohio, and the Canadian province of Ontario. Some out-of-state metropolitan areas extend into this part of Michigan, such as South Bend, Elkhart, Michigan City, Toledo, and Sarnia. This part of the state is extremely well-served by the Interstate Highway System, and many colleges and State

universities are found throughout the area. Many features of historic and scenic interest draw tourists from other parts of the state and country. University sports venues, the Michigan International Speedway, minor league baseball, many different museums, zoos, professional theaters, historic sites, and well-known manufacturing facilities (e.g. Kellogg breakfast cereals) are numbered among the area's many cultural attractions.

The largest urban areas connected with the Southern Lower Peninsula (outside of Metropolitan Detroit) are:

Grand Rapids	589,060 (Grand Rapids UA plus exurban Lowell, Dorr, Sparta, Cedar Springs UAs)
(Toledo, OH-MI)	507,643 (Monroe County has suburban/exurban parts of the Toledo UA.)
Flint	362,078 (or 370,307 if suburban Holly is included from the Metro Detroit area)
Lansing	319,849 (Lansing's UA of 313,532 plus exurban Williamston's UA of 6,317)
(South Bend, IN-MI)	278,165 (Some suburban/exurban parts are located in Berrien and Cass counties.)
Kalamazoo	221,443 (Kalamazoo's UA of 209,703 plus exurban Otsego-Plainwell pop. of 11,740)
(Sarnia-Port Huron, ON-MI)	176,661 (Port Huron UA from 2010 U.S. census + Sarnia 2011 population statistic)
Muskegon	171,848 (161,280 Muskegon UA, plus exurban Whitehall-Montague UA of 10,568)
(Elkhart, IN-MI)	143,592 (Some suburban/exurban parts are located in Berrien and Cass counties.)
Saginaw	126,265
Holland	99,941
Jackson	90,057
Port Huron	87,106 (Michigan UA only, not including the Canadian Sarnia area)
Battle Creek	78,393
Bay City	70,585
(Michigan City-LaPorte, IN-MI)	66,025 (One exurb of the UA is located in the southwest corner of Berrien Co.)
Benton Harbor-St. Joseph	61,022
Midland	59,014
Monroe	51,240 (Detroit's southern suburbs do overlap with Monroe's northern suburbs.)
Adrian	44,823 (in Lenawee County)
Mt. Pleasant	37,447 (in Isabella County)
Owosso	22,426 (in Shiawassee County)
Alma-St. Louis	16,924 (in Gratiot County)
Coldwater	16,876 (in Branch County)
Ionia	14,409 (in Ionia County)
Big Rapids	14,241 (in Mecosta County)
Lapeer	13,424 (in Lapeer County)
Sturgis	13,040 (in St. Joseph County)
Charlotte	12,682 (in Eaton County)
Hillsdale	11,646 (in Hillsdale County)
Paw Paw Lake-Hartford	11,589 (in Berrien and Van Buren Counties)
Three Rivers	10,820 (in St. Joseph County)
Greenville	9,743 (in Montcalm County)
Albion	9,219 (in Calhoun County)
Paw Paw	8,684 (in Van Buren County)
St. Johns	8,425 (in Clinton County)
Hastings	7,713 (in Barry County)
Marshall	7,683 (in Calhoun County)
Berrien Springs	7,358 (in Berrien County)
Allegan	6,322 (in Allegan County)
Dowagiac	6,082 (in Cass County)
South Haven	5,791 (in Van Buren County)
Belding	5,789 (in Ionia County)
Eaton Rapids	5,408 (in Eaton County)
Caro	5,113 (in Tuscola County)
Portland	5,020 (in Ionia County)
Frankenmuth	4,972 (in Saginaw County)
Durand	4,854 (in Shiawassee County)
Wayland	4,518 (in Allegan County)

Perry	4,290 (in Shiawassee County)
Constantine	4,074 (in St. Joseph County)
Coopersville	3,951 (in Ottawa County)
Dundee	3,799 (in Monroe County)
Imlay City	3,792 (in Lapeer County)
Vassar	3,714 (in Tuscola County)
Bad Axe	3,490 (in Huron County)
Blissfield	3,303 (in Lenawee County)
Middleville	3,236 (in Barry County)
Somerset	2,910 (in Hillsdale County)
Sandusky	2,775 (in Sanilac County)
Brooklyn	2,773 (in Jackson County)
Almont	2,719 (in Lapeer County)
Gun Lake	2,660 (in Barry County)
Douglas-Saugatuck	2,570 (in Allegan County)

The Southern Lower Peninsula (outside of Metro Detroit) has a larger proportion of its workers in the manufacturing sector than other parts of the state. Its percentages employed in educational and other services are significantly larger than for Michigan as a whole. It has many colleges and universities. Lansing is the state capital and contains many government agencies. Among the many recreational and cultural attractions are large stadiums and performance venues, which tend to require special preparation and management when it comes to protecting attendees from threats and hazards. Various convention centers and downtown areas tend to regularly attract large numbers of persons, who similarly may require special planning to protect them from threats and hazards.

4. Metropolitan Detroit

This area contained the first large Michigan settlements, which developed into the expanding City of Detroit throughout the industrial revolution and then became world-famous as "The Motor City." The largest American automobile companies tended to develop in this area of Michigan, and eventually became "the big three"—Ford, General Motors, and Chrysler, with their world headquarters located in Dearborn, Detroit, and Auburn Hills, respectively. Although the area's population increased by the greatest amount during the first half of the 20th Century (Detroit's peak census population was in 1950, at 1,849,568 persons), the metro area continued to increase slowly for 50 years thereafter—until the most recent census revealed the effects of various economic challenges, which registered an overall decline of modest proportions (while most of the metropolitan counties continued to grow at a decent rate).

The largest urban areas in the Metropolitan region, according to the 2010 U.S. census, are:

Detroit 3,863,533 (or 4,182,779, including 319,246 in the Windsor area in Ontario)

(NOTE: 3,734,090 are in Metro Detroit, plus 119,509 in the Howell-Brighton suburban UA and the exurbs of Richmond and Fowlerville, 6,140 and 3,794 respectively.)

Ann Arbor 313,536 (306,022 in Ann Arbor plus 7,514 in the exurb of Milan)

(NOTE: Detroit and Ann Arbor might be considered one Metro area of 4,177,069; or 4,496,315 with Windsor.)

Holly 8,229 (suburb of Flint)

Chelsea 5,329

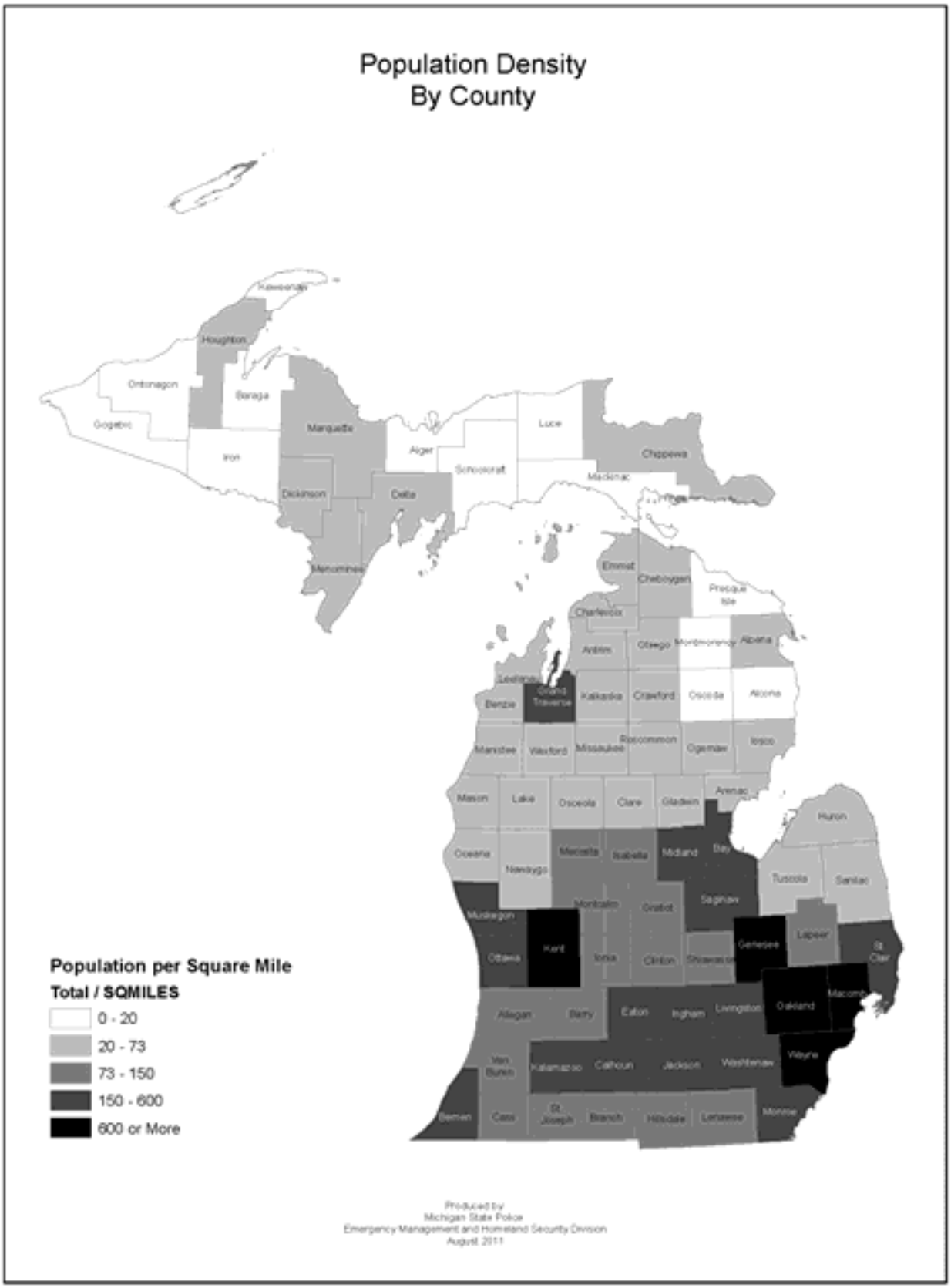
The area employs a larger percentage of its workforce in certain economic sectors than other parts of Michigan do. These sectors include wholesale trade, transportation and warehousing, information, finance and insurance, real estate, management, and professional, scientific, and technical services. The arts, entertainment, and recreation sector is also a bit larger, percentagewise, than it is in other parts of the State.

Michigan's Significant Hazards in each Geographic Division

The following list summarizes the hazards that have been proven to be likely within the following geographic divisions within Michigan. A hazard is still possible in these areas even if it is not listed here, but this list merely provides a rough indicator of the different kinds of events that are typically identified as a major threat within local and regional hazard analyses across different parts of the State.

1. Upper Peninsula (15 counties)
   Natural Hazards: Thunderstorms, Severe Winter Weather, Severe Winds, Tornadoes, Extreme Temperatures, Flooding, Shoreline Hazards, Dam Failures, Drought, Wildfires, Invasive Species, Subsidence.
   Technological Hazards: Structural fires, Infrastructure Failures.
   Human-Related Hazards: Civil Disturbances, Nuclear Attack, Public Health Emergencies, Terrorism.
2. Northern Lower Peninsula (29 counties)
   Natural Hazards: Thunderstorms, Severe Winter Weather, Severe Winds, Tornadoes, Extreme Temperatures, Flooding, Shoreline Hazards, Dam Failures, Drought, Wildfires, Invasive Species.
   Technological Hazards: Structural fires, Scrap Tire Fires, Oil and Gas Well Accidents, Infrastructure Failures.
   Human-Related Hazards: Nuclear Attack, Public Health Emergencies, Terrorism.
3. Southern Lower Peninsula (34 counties)
   Natural Hazards: Thunderstorms, Severe Winter Weather, Severe Winds, Tornadoes, Ice/Sleet Storms, Extreme Temperatures, Flooding, Shoreline Hazards, Dam Failures, Drought, Invasive Species, Earthquakes.
   Technological Hazards: Structural fires, Scrap Tire Fires, Hazardous Materials Incidents, Nuclear Power Plant Emergencies, Pipeline Accidents, Oil and Gas Well Accidents, Infrastructure Failures, Energy Emergencies, Transportation Accidents.
   Human-Related Hazards: Civil Disturbances, Nuclear Attack, Public Health Emergencies, Terrorism.
4. Metropolitan Detroit (5 counties)
   Natural Hazards: Thunderstorms, Severe Winter Weather, Severe Winds, Tornadoes, Ice/Sleet Storms, Extreme Temperatures, Flooding, Shoreline Hazards, Dam Failures, Drought, Invasive Species.
   Technological Hazards: Structural fires, Scrap Tire Fires, Hazardous Materials Incidents, Nuclear Power Plant Emergencies, Pipeline Accidents, Infrastructure Failures, Energy Emergencies, Transportation Accidents.
   Human-Related Hazards: Civil Disturbances, Nuclear Attack, Public Health Emergencies, Terrorism.

Michigan's position as a national and international manufacturing and business center virtually assures that the state will remain vulnerable to hazardous material incidents and other technological hazards. Extensive planning and preparation has been done to aid in responding to these types of events, and that work must continue and perhaps even be expanded as the number and potential impacts of technological hazards continues to grow.


Population Density
By County
Population per Square Mile
Total / SQMILES
0 - 20
20 - 73
73 - 150
150 - 600
600 or More
Produced by
Michigan State Police
Emergency Management and Homeland Security Division
August 2011

The following table presents selected economic information for Michigan and its four geographic divisions (as defined in this document). Various economic sectors have been listed, along with their shares of Michigan's annual payroll and employment (as of March 2009 information from the County Business Patterns source). The percentage of total employment within each geographic division is also presented. Please note that because of the way this data was compiled from subcomponents (some of which were unavailable), the division totals do not equal 100%. Nevertheless, this information is considered useful to identify the sectors that are comparatively more important in different parts of the state.

2009 County Business Patterns		**MICHIGAN**	**MICHIGAN**	**U.P.**	**N.L.P.**	**S.L.P.**	**Metro**
NAICS code	**NAICS code description**	**% annual payroll**	**% of workers**	**% of workers**	**% of workers**	**% of workers**	**% of workers**
------	Total for all sectors	100.0%	100.0%	89.1%	94.1%	97.1%	97.9%
11----	Forestry, fishing, hunting, and Agriculture Support	0.1%	0.1%	0.6%	0.2%	0.0%	0.0%
21----	Mining, quarrying, and oil and gas extraction	0.2%	0.2%	0.0%	0.8%	0.1%	0.0%
22----	Utilities	1.4%	0.6%	0.3%	0.1%	0.0%	0.1%
23----	Construction	4.2%	3.4%	4.9%	4.9%	3.6%	3.1%
31----	Manufacturing	16.8%	13.9%	16.6%	14.7%	17.3%	11.1%
42----	Wholesale trade	6.4%	4.7%	2.2%	2.5%	4.6%	5.1%
44----	Retail trade	7.4%	13.2%	16.9%	17.9%	14.1%	12.2%
48----	Transportation and warehousing	2.7%	2.8%	1.9%	1.7%	2.6%	3.2%
51----	Information	3.1%	2.2%	1.1%	1.2%	1.7%	2.7%
52----	Finance and insurance	6.4%	4.6%	3.5%	3.5%	4.0%	5.0%
53----	Real estate and rental and leasing	1.2%	1.5%	0.9%	1.0%	1.3%	1.8%
54----	Professional, scientific, and technical services	11.3%	7.1%	3.9%	3.5%	4.2%	8.5%
55----	Management of companies and enterprises	7.1%	3.0%	0.0%	0.3%	1.6%	4.1%
56----	Administrative & Support & Waste Management & Remediation Services	5.8%	7.8%	4.0%	2.8%	6.0%	7.6%
61----	Educational services	1.3%	2.1%	0.4%	0.8%	2.2%	1.7%
62----	Health care and social assistance	17.3%	16.8%	13.9%	19.6%	17.2%	16.5%
71----	Arts, entertainment, and recreation	1.1%	1.5%	0.8%	1.3%	1.3%	1.7%
72----	Accommodation and food services	3.2%	9.7%	12.5%	12.5%	10.0%	9.2%
81----	Other services (except public administration)	2.8%	4.7%	4.7%	4.9%	5.2%	4.3%
99----	Industries not classified	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Michigan, which contains three operating commercial nuclear power plants, has continued to develop and expand its capabilities to respond to a nuclear accident. Although stringent steps are taken at each plant to ensure safe and trouble-free power generation, accidents can occur. To combat that possibility, Michigan must continue to be a leader in nuclear safety to ensure that the state's residents are adequately protected from the potentially harmful effects of an accidental radioactive material release.

Unfortunately, Michigan has experienced major acts of terrorist-like criminal action. On May 18, 1927, a disgruntled taxpayer set off a bomb in a schoolhouse in Bath, killing 45 persons (mostly children) and injuring 58 others. Most recently, in 2009, Michigan narrowly avoided having a major terrorist act occur on its soil, as an attempt to bomb a passenger airline over Detroit did not succeed. As evidenced by the mounting history of criminal and terrorist events and plots—the bomb blasts at the World Trade Center in 1993, the tragic destruction of the Murrah Federal Center in Oklahoma City in 1995, the September 2001 terrorist strikes in New York City and Washington D.C., the 1996 Summer Olympics bomb in Atlanta, lethal shooting events at Columbine High School (1999), Fort Hood in Texas (2009), and Washington D.C. in 2002—constant vigilance is needed by all citizens to prevent and deter future events of this type.

Finally, substantial actions must be taken to mitigate the hazards outlined in this report. Hazard mitigation is defined as "any action taken before, during or after a disaster or emergency situation to permanently eliminate or reduce the long-term risk to human life and property from natural, technological and human-related hazards." Hazard mitigation actions, especially if implemented in a coordinated, inter-governmental, inter-disciplinary manner, can effectively reduce the damage, suffering, injury, and loss of life and property associated with these hazards. That, in turn, helps reduce disaster response and recovery costs, saving untold millions of dollars in public and private disaster relief assistance. In addition, hazard mitigation can greatly reduce the social, economic and political disruptions that disasters bring to bear on Michigan communities. The old adage "an ounce of prevention is worth a pound of cure" is certainly true when it comes to disasters.

It is for those reasons that this Hazard Analysis is contained within the 2014 Michigan Hazard Mitigation Plan and coordinated with the Michigan Emergency Management Plan, the Michigan Citizen-Community Emergency Response and Coordinating Council, the Threat and Hazard Identification and Risk Assessment process (THIRA), and other plans, groups, agencies, and processes. Continuing to promote and advance the art and science of hazard mitigation will help ensure that Michigan's citizens are protected, to the maximum extent possible, from the harmful impacts of future disasters.

Local Hazard Loss Estimation Tables

A series of tables has been added to the sections of this plan that analyze natural hazards. These tables cover all 83 Michigan counties, for each natural hazard with records available in the National Climatic Data Center online database, and provide a more valuable and accessible method of estimating average losses for each hazard type. Consolidated tables were also provided, at the start of the hazard analysis section, showing the average annual impacts of each hazard at a statewide level. In addition, Attachment A provides more detailed information, including that for (1) state owned/operated critical facilities located in identified hazard areas, and (2) potential dollar loss estimates for those facilities, where appropriate, for significant natural hazards covered in this plan. However, because of the potential for misuse of data about Michigan's critical facilities, copies of this plan that are available for general distribution do not include these details.

Note: Individual county maps that used to be suppressed in earlier editions of the MHMP are no longer referenced here. With the substantial expansion of Geographic Information Systems (GIS), the analysis of maps has shifted to a predominantly digital format. The county maps that had previously included information about critical facilities in each county, but had been produced at the state rather than the local level, should be considered as an inferior substitute for the full hazard mitigation plans that have been developed in most Michigan Counties since the first edition of the MHMP had come out in 2005. Some of the GIS data and maps exist at the state level are available for review by appropriate emergency management officials only. Over the past 10 years, GIS technology has been used to substantially expand the hazard analysis portion of this plan, as well as the assessment of state owned/operated critical facilities included in Attachment A. The maps that had been included in the unedited versions of previous MHMP editions have been replaced by newer, digital system information. Rather than a static set of county maps that contained sensitive information not available for public perusal, this plan has switched over to GIS representations that indicate hazard-specific risks for each county, at a statewide or regional scale that is suitable for widespread public distribution, and customized to suit the needs of this document.

NOTE: Not all hazards are considered appropriate for this type of analysis, and therefore the loss estimates have focused only on particular types of natural hazards. For example, various human-related hazards that do not have

specific risk locations and an agreed-upon method of loss estimation, such as public health emergencies, were not given this type of analysis here. Natural hazards were the ones emphasized, in accordance with federal guidelines.

Inventorying Assets: State Owned/Operated Critical Facilities

Several hundred state owned/operated critical facilities have been identified by MSP/EMHSD and partnering state agencies. These facilities were identified using a federally-provided definition of a critical facility as well as the results of a continuity of operations planning (COOP) effort undertaken by Michigan's state agencies. An updated list of facilities was provided by the Michigan Department of Technology, Management, and Budget, in 2013, and was used as the basis for compiling a newly updated list of critical facilities for this plan. This included a careful comparison with the lists in previous editions of this plan, to verify that comparable standards were being used to assign or verify the criticality of new facilities. Some facilities (e.g. State Police posts) had closed down and were removed from the list, while other facilities had been recently built and were added to the list. New information about property values (or, when unavailable, an estimate of those values based upon the floor area of the facility, its type of use, and the standard values recently provided in RS Means, using its web site for the most recent 2014 figures) was included to enable the calculation of potential losses from each hazard.

*__**VERY IMPORTANT NOTE REGARDING SUPPRESSION OF DATA**__: All references to specific state owned / operated critical facilities have been **SUPPRESSED** in the federal review and public distribution versions of this plan due to security concerns. This includes both text references and data in tables. These materials are maintained by the MSP/EMHSD and are available for inspection by appropriate emergency management officials only. It is recognized that the suppression of such information changes the character and usefulness of this plan, but homeland security concerns dictate that such measures must be taken. Although the State of Michigan has passed legislation that protects certain types of homeland security and planning information from release under the Freedom of Information Act, the same type of FOIA exemption is not in place at FEMA, and therefore FEMA has also been provided with a data-suppressed edition of this plan. Suppressed information appears only in a master copy of the plan maintained by the MSP/EMHSD, for authorized users to see.

Facility vs. Function

When determining the criticality of state facilities, it is necessary to differentiate between the functions performed within the facility, and the facility itself. More often than not, the real critical assets of a facility are the workers, equipment and information within the facility, not the actual building or location. In other cases, it is the building itself that is critical because the functions performed at the facility are necessarily intertwined with the structure. For example, there may be specialized equipment that cannot be moved or replaced, or the facility may be critical because of its location, or perhaps the unique engineering aspects of the facility cannot be easily replicated in another structure. A good example would be state correctional facilities, which typically are hardened structures with very specialized security features that are generally not found in other buildings. Another example would be a group congregate care facility (such as a center for juvenile offenders) that has unique architectural and engineering features not found in most other structures.)

Utility Infrastructure

This plan will only address those critical state-owned and operated infrastructures identified in the "State Owned/Operated Critical Facilities" table above. Locally-owned and operated critical infrastructure is addressed as appropriate in local hazard mitigation plans. Privately-owned and operated critical infrastructure is addressed in plans developed by the owner/operator of the infrastructure—most likely as part of a larger critical facility/infrastructure program under the umbrella of homeland security. (However, a generalized hazard vulnerability analysis for all types of critical infrastructure can be found in the "Vulnerability of State Owned/Operated Critical Facilities" section below and in Attachment A. This generalized analysis for critical infrastructure – called "lifelines" – is intended to show the types of infrastructures that are present in Michigan and to identify the major hazards to which the infrastructures are most vulnerable. It is based on general vulnerability assessments conducted by the American Lifelines Alliance, as well as damage assessment findings from recent Michigan natural disasters.)

Vulnerability of State Owned/Operated Critical Facilities

Identification of state owned/operated critical facilities that are vulnerable to various types of hazards is a key component of this plan. By identifying those facilities that are most vulnerable to hazards, cost-effective mitigation

measures can be developed and implemented to help permanently reduce or eliminate that vulnerability. These measures will help ensure that the most critical assets of state government remain operational at all times—and especially in times of disaster or emergency—to provide for the continuation of emergency operations, continuity of government, critical public safety, health care, transportation and educational functions, and the provision of other essential services to the public.

General Facility Vulnerability to Natural Hazards

The vulnerability of a state owned or operated critical facility is a function of its location with respect to identified natural hazard areas, building specific information such as its design, construction type and material, the number of individuals typically present in the facility, and the types of functions performed at the facility. In Michigan, all state owned/operated critical facilities have a general exposure to wind, snow, ice, and temperature extremes. In addition, critical facilities located in floodplains and other low-lying areas have a vulnerability to flooding. Facilities located in some areas may also be vulnerable to land subsidence due to previous mining activities or other causes. Facilities located in extreme southwestern and southern Lower Michigan may be vulnerable to minor damage in the event of a magnitude 7.6 earthquake in the New Madrid Seismic Zone. Critical infrastructures such as natural gas and petroleum pipelines that pass through this area may be damaged as well, creating possible fuel shortages within the state. Several state owned/operated facilities could potentially be affected by a failure that partially or completely inundates the hydraulic vulnerability zone ("footprint") of a high or significant hazard dam as determined by the Michigan Department of Environmental Quality (MDEQ). There were also a few state owned/operated facilities are located within a "high concern" wildland/urban interface area as identified by the Michigan Department of Natural Resources (MDNR). The MDNR's wildfire assessment methods are in transition, and a previous plan's map of wildland/urban interface areas has been replaced with the consideration of actual wildfire incidents in different counties, as described in that subsection of this plan's hazard analysis. For more information about facility risks, please see Attachment A.

"Lifeline" Vulnerability to Natural Hazards

"Lifelines" (critical utility and transportation infrastructure) are essential to the health, safety, and general welfare of the residents of Michigan. Some lifelines, such as highways, water supply pipelines, power transmission lines, and petroleum pipelines, are linear in nature with key links nodes, such as pumping stations and compressor stations, located at specific locations. Other lifelines, such as bridges, water treatment plants, petroleum refineries, and storage tanks, are more location-specific. Linear lifelines, because of the distances they cover, may be exposed to a full range of natural hazards. Location-specific lifelines, on the other hand, will only be exposed to the natural hazards that are present at that particular location. Most lifelines are designed and built in such a manner (usually with hardened materials) to withstand a wide variety of natural forces. For example, buried pipelines and transmission lines have almost no vulnerability to wind damage because they are protected by the surrounding soil. (Underground installations, however, may be more vulnerable to earthquake or subsidence threats or accidental breakage during construction activities.) Most highways, bridges, and other public transportation facilities are able to withstand a wide variety of natural forces and still remain intact and operational.

As indicated earlier, this plan addresses those critical infrastructures (lifelines) that are owned and operated by the State of Michigan as identified in the "State Owned/Operated Critical Facilities" table. Critical infrastructures owned/operated by local governments or private entities will not be included in this plan and are clearly beyond the scope of this planning effort. However, the "General Natural Hazard Vulnerability: Lifelines" table found in Attachment A does provide a listing of the general types of lifelines present in Michigan and identifies the major natural hazards to which the lifelines are most vulnerable. The information for that table was based on general vulnerability assessments conducted by the American Lifelines Alliance, as well as damage assessment findings from recent Michigan natural disasters. In that table, each lifeline or lifeline component that potentially has a high level of vulnerability for a particular natural hazard is marked with a "•". This assessment is provided for general reference purposes only and only highlights potential key vulnerabilities. An indication of potentially high vulnerability to a given hazard means that the lifeline or lifeline component may incur 1) significant physical damage, 2) a denial of use or loss of function, or 3) both physical damage and loss of function. For example, snow and ice may cause a temporary loss of function on a stretch of highway but rarely causes permanent physical damage to the facility itself. On the other hand, severe winds may cause both physical damage and a loss of function to overhead electrical transmission lines if they are blown down.

Loss Estimations for State Owned/Operated Critical Facilities

Attachment A contains a series of tables and maps that calculate potential losses for critical state owned / operated facilities from the various types of natural hazards examined in this plan. Following each loss estimation table is narrative that explains the methodology and information sources used in calculating the facility loss estimations, as well as any other required background information about the facilities or the hazard being examined.

Loss Estimations by Local Jurisdiction and Hazard

In addition to loss estimation tables for state owned/operated critical facilities, Attachment A also includes some additional information, beyond that already provided in the hazard analysis, in the form of a series of tables that calculate the potential impacts of natural hazards on each of Michigan's 83 counties. Attachment A includes appropriate text descriptions to explain the methodology and information sources used in these assessments, as well as some other background information.

State/Local Capability Assessment: Existing Hazard Mitigation Tools and Measures

This section of the plan expands upon many of the hazard mitigation strategies listed within each hazard subsection, with a greater emphasis on those strategies that can be implemented or promoted in some manner by staff and/or funding at the level. This description includes some strengths and weaknesses of hazard mitigation strategies, which is useful to explain the types of considerations that may make certain strategies more or less feasible at the state government level, or for promotion by state government.

Land Use / Development Measures

The relationship between wise land use planning and the reduction of a community's exposure and vulnerability to hazards is clear. Experience has shown that those communities that carefully plan the location, type, and structural requirements of development to avoid (to the extent possible) hazardous areas and vulnerable structures suffer far less disaster-related damage and impacts than do communities that don't carefully plan for development. The benefits of wise land use and development planning, from a disaster recovery standpoint, include:

- Less disruption to a community's economic, social, and physical structure.
- Less impact on the community's tax base.
- Less impact on the provision of essential services.
- Less financial impact in terms of local participation in disaster program cost-sharing and the rebuilding of damaged community facilities.

In addition, communities that are more vulnerable to disaster damage may be less likely to be looked upon favorably by potential business enterprises as a safe, secure place in which to do business. Clearly, wise land use planning and development practices have very practical ramifications from that standpoint of attracting and retaining business and industry in the community.

Prevention is the Key

Preventing land use or development related problems in the first place **(preventive mitigation)** is much more prudent and desirable than attempting to go back and correct problems **(corrective mitigation)** at a later time. The old adage "an ounce of prevention is worth a pound of cure" is certainly true when it comes to land use planning and community development. Buildings, homes, businesses, and public infrastructure that are in harm's way or vulnerable by design or construction are doomed to eventual failure. It might not occur overnight, but experience has shown that eventually it will occur. The unfortunate part is that the community is left with the job of picking up the pieces in the aftermath of an emergency or disaster.

Hazard Mitigation is Primarily a Local Function

Fortunately, local governments have many tools available to guide the type, location and structural requirements of development. For that reason, and since development occurs primarily at the local level, hazard mitigation is inherently a local government function. State government has an important role to play, in that laws and processes governing the use of land and development of property originate at the state level. In addition, state agencies administer a wide variety of programs that affect – either directly or indirectly – the development and use of land. Therefore, successful implementation of a program to reduce vulnerability to hazards must, out of necessity, be a joint cooperative effort between the State and local governments. State government provides the means (i.e., enabling laws and local governing authority) for regulating land development, and local governments put that means to use and actually make land use / development decisions.

For land use / development decision-making to be effective in limiting or eliminating hazard risk and vulnerability, local and state actions must be carefully coordinated. The State must ensure, through appropriate legislation and rules/regulations, that local governments have the necessary means to effectively guide and manage land use change

and development. In addition, the State must ensure that its development related actions do not contribute to increasing hazard risk and vulnerability.

Local governments, in turn, must make good land use decisions and exercise prudent stewardship of the land development process within their communities. Adequate guidance, oversight, and enforcement at the local level are critically important to successfully mitigating hazard risk and vulnerability. Successful implementation of this process will help ensure that the State of Michigan's land use / development pattern lends itself to a reduction, to the extent possible, of risk and vulnerability to natural, technological and human-related hazards.

Existing Measures and Their Effectiveness at Mitigating Hazards

Local governments in Michigan can utilize the following measures to effectively guide land use and development:

- Comprehensive planning;
- Zoning ordinances;
- Building codes;
- Subdivision regulations;
- Special area, use and design regulations; and
- Capital improvements planning.

These measures can be used to reduce risk and vulnerability to many types of hazards. However, political, social and economic pressure at the local level often leads to approval of land uses and developments that may not be appropriate for a particular site or area. In some instances, code enforcement may be a problem. In others, adequate funding may not be available to support planning or regulatory activities, or there may be a lack of community support for such activities. The end result is that local communities may not be able to effectively utilize the measures they have at their disposal.

The one commonality that these land use / development guidance measures have is that they are coordinated, at least to some degree, by a planning commission. In Michigan, local and regional planning commissions are authorized to develop, review and implement long-range, comprehensive development plans. Although local planning commissions in Michigan are primarily advisory bodies as opposed to regulatory ones, they can wield power and influence in land use and development decisions. Similarly, regional planning commissions have authority to review and comment on local federally funded development projects, which also places them in a position to offer insight on possible mitigation opportunities within or affecting local jurisdictions.

These measures provide local governments with the tools necessary to effectively guide and regulate land use and development. The primary mitigation opportunities lie not in the <u>structure</u> of the measures, but in the <u>coordination and application</u> of the measures at the local level.

Some planning commissions have been successful in effectively coordinating land use / development measures to reduce community risk and vulnerability to hazards. However, community decision makers do not always follow the recommendations of their planning commission. Often, local economic considerations take precedence over the need for mitigation. This may be compounded, at least in part, by differences or bias in risk perception. For example, certain hazards (or perhaps hazards in general) may not be viewed as a threat worth addressing, other issues may be ranked higher than hazard risk reduction, or the community may not be aware of the potential impacts of a hazard. Also, time horizons vary a great deal. For example, a homeowner has a lengthy time horizon because they usually want to protect their investment for as long as possible. The bank holding the mortgage has a 30-year time horizon (the period for which the loan proceeds are at risk), although some lending institutions are remarkably short sighted when it comes to lending money for risky developments. The developer who proposes a project has a time horizon of only a few years, long enough to build a structure and then sell it. A political leader is often operating under a time horizon that may expire before the next disaster, and thus may choose to let the next generation of decision makers deal with the issue.

Planning commissioners may also fall under this last category. They may not be overly concerned with development issues that will crop up after their term expires. Another obstacle may be a general lack of knowledge in the planning

community (both professional practitioner and commissioner) about the relationship between sound land use planning and development decisions and the community's risk and vulnerability to hazards. Many planners don't know a great deal about hazard mitigation and emergency management because they never received training in these disciplines and they are not part of their day-to-day work activities.

The general hazard mitigation goal of promoting safe, sustainable development that results in economically, socially and physically viable communities is virtually identical to the overall mission of the urban planning profession. However, more often than not, hazard vulnerability reduction is not considered much when decisions are made about land uses and land development because the concept is not formally institutionalized in the decision making process. Institutionalizing hazard mitigation principles into land use planning and development decision making is the key to limiting community risk and vulnerability to hazards. That institutionalization must occur at the policy making level (the "tools of the trade") – incorporating hazard mitigation into the comprehensive plan, zoning ordinance, capital improvements plan and other mechanisms for guiding land development – and at the implementation level where the actual land use / development decisions are made by the planning commission and local governing body.

Following is a description of the major provisions of the aforementioned basic land use / development measures as they relate to the implementation of hazard mitigation objectives:

Comprehensive Planning

The purpose of a comprehensive plan is to establish an orderly, convenient, efficient and enjoyable environment in a community, and to improve the quality of life for all its citizens. A comprehensive plan provides for future development or improvement of the land use pattern and public service program of the community. In Michigan, planning commissions are required to prepare and adopt a comprehensive plan if the community is enforcing a zoning ordinance. (The zoning ordinance must be based on an adopted comprehensive plan to be legally defensible and enforceable.) This is probably the most significant responsibility of the planning commission. Once adopted (by the planning commission and/or the community's legislative body), the comprehensive plan serves as the foundation document for the preparation and subsequent implementation of other land use / development measures such as the zoning ordinance, public works capital improvements plan, subdivision regulations, and special area, use or design regulations. All of these other measures can be used to implement hazard mitigation measures, so the importance of the comprehensive plan in relation to mitigation cannot be understated.

In terms of content, comprehensive plans typically address such subjects as land use, transportation, utilities, schools, public facilities, parks, economic development, and other subjects that relate to the physical development of the community. Although there are no absolute required elements for comprehensive plans in Michigan, 2006 PA 110 (Michigan Zoning Enabling Act*) does provide some guidance with regard to the types of zoning districts that may be established. Section 201 (1) of the Act states: "A local unit of government may provide by zoning ordinance for the regulation of land development and the establishment of one or more districts within its zoning jurisdiction which regulate the use of land and structures to meet the needs of the state's citizens for food, fiber, energy, and other natural resources, places of residence, recreation, industry, trade, service, and other uses of land, to ensure that use of the land is situated in appropriate locations and relationships, to limit the inappropriate overcrowding of land and congestion of population, transportation systems, and other public facilities, to facilitate adequate and efficient provision for transportation systems, sewage disposal, water, energy, education, recreation, and other public service and facility requirements, and to promote public health, safety, and welfare."

Section 201 (3) of the Zoning Enabling Act provides for the establishment of zoning districts to address special land use problems or achieve specific land management objectives. It states: "A local unit of government may provide under the zoning ordinance for the regulation of land development and the establishment of districts which apply only to land areas and activities involved in a special program to achieve specific land management objectives and avert or solve specific land use problems, including the regulation of land development and the establishment of districts in areas subject to damage from flooding or beach erosion." This allows for such activities as floodplain management under the National Flood Insurance Program (NFIP) and coastal zone management under the Michigan Natural Resources and Environmental Protection Act (1994 PA 451, as amended). Although the Act specifically mentioned flooding and beach erosion hazards as examples, this provision is certainly flexible enough to address other known hazard areas in a community as long as the regulatory measure is legally defensible and consistently applied.

The Michigan Zoning Enabling Act, and especially Section 201 (3), appears to provide sufficient flexibility and regulatory framework to allow communities to effectively use comprehensive planning and zoning to reduce their natural hazard risk and vulnerability.

***Background Notes:** On July 1, 2006, Michigan's three zoning enabling acts (one each for cities and villages, townships, and counties) were officially repealed and combined into one new statute, the Michigan Zoning Enabling Act (2006 PA 110). The new Zoning Enabling Act has many improvements over the former enabling legislation. It is roughly one-third the length of the previous acts, the language is clearer, and the notification process is easier and more consistent. Enactment of the Zoning Enabling Act was the culmination of years of work by many stakeholder groups, including the Michigan Association of Planning, Michigan Townships Association, Michigan Municipal League, Michigan Association of Counties, Michigan Homebuilders Association, Michigan Realtors Association, Michigan Department of Environmental Quality, and the Michigan Department of Energy, Labor and Economic Growth. Unification and modernization of the three zoning enabling acts was also one of the recommendations of the final report of the Michigan Land Use Leadership Council in August of 2003. (Note: Only counties, cities, villages, and townships that have a zoning ordinance are affected by the new Zoning Enabling Act.)

On February 29, 2008, 2006 PA 110 was amended by 2008 PA 12 to make several needed "corrective amendments" to various administrative mechanisms and processes contained in the original act. Act 33 of 2008, the Michigan Planning Enabling Act, unified and amended Michigan's three planning enabling acts (one each for cities and villages, townships, and counties) into a single, coordinated planning act. This new act was widely supported by various professional and advocacy organizations, with the anticipation that it would do for planning what the Michigan Zoning Enabling Act (described above) had done for zoning. The enactment of a new coordinated planning act was also one of the recommendations contained in the final report of the Michigan Land Use Leadership Council in August 2003. The new act was designed to strengthen the ability of local communities to effectively use comprehensive planning along with zoning and other regulatory tools.

Zoning Ordinances

A zoning ordinance is probably the most effective measure a community has for guiding and regulating development and the land use pattern, and it can be very effective in mitigating hazard risk and vulnerability. The zoning ordinance provides a mechanism for implementing the policy decisions articulated in the comprehensive plan concerning the desired locations of various land uses and public facilities. The zoning ordinance is based on the comprehensive plan and therefore is developed and adopted after the comprehensive plan has been formally adopted by the community. One major difference between the two mechanisms is the timeframe upon which they are based. Generally, the comprehensive plan is designed to guide development for the next 20 years or more, whereas the zoning ordinance will typically be adopted on the basis of a 7-10 year land use development need projection.

A zoning ordinance typically addresses 3 primary areas: 1) the use of land and structures and the height and bulk of structures; 2) the density of population and intensity of land and structural use; and 3) the provision for space around structures (i.e., requirements for side yards, rear yards, open space, building setback lines, etc.)

Some zoning ordinances may specifically address potential hazards to life and property, although there is no requirement to do this. The ordinance itself consists of a map or maps delineating the zoning districts in the community where various land uses will be allowed, and an accompanying set of administrative procedures, standards and methods for enforcing the zoning regulations. Zoning districts typically include various types of industrial, commercial, residential, agricultural, and public facility uses. Specific zoning districts are tailored to the particular needs of the community. For example, communities that have a significant amount of lakefront properties may have a special zoning district for residential development around lakes.

Although there are a variety of standard zoning districts, there are no formal legal requirements regarding the type of districts that must be included in an ordinance. As indicated in the "Comprehensive Planning" section above, the new Michigan Zoning Enabling Act is suggestive but not prescriptive in its provisions for zoning districts. Section 201 (1) of the Act suggests a variety of land uses that may be addressed by formal zoning districts but it does not mandate a standardized list of zoning districts that must be applied in each Michigan community that has a zoning ordinance. Section 201 (1) is sufficiently flexible to allow each community to develop a zoning ordinance to meet its individual circumstances. Obviously, any zoning ordinance must allow sufficient uses to be legally defensible if challenged in court. Essentially, it is left up to each planning commission to determine the type of zoning districts that are appropriate for the community, based on its unique characteristics. Section 201 (3) of the Act also provides communities with the option to establish zoning districts and regulate land uses to address specific land use or land management problems. As indicated in the "Comprehensive Planning" section above, the Michigan Zoning Enabling Act provides sufficient flexibility and regulatory framework to allow communities to use comprehensive planning and zoning to effectively reduce their natural hazard risk and vulnerability.

Building Codes

Building codes are designed to ensure that a building or other structure will be constructed in such a manner as to be safe for occupancy and use. These codes also regulate health and sanitation requirements for water, ventilation, plumbing, electricity, mechanical equipment, heating and air conditioning. They also contain minimum construction standards for natural hazard resistance.

Pursuant to 1972 PA 230, adopted November 5, 1974 and amended by 1999 PA 245, all communities in Michigan are subject to the State Construction Code, which establishes general minimum construction standards for buildings and structures in all Michigan municipalities. The State Construction Code is a compilation of the International Residential Code, the International Building Code, the International Mechanical Code, the International Plumbing Code published by the International Code Council, the National Electrical Code published by the National Fire Prevention Association, and the Michigan Uniform Energy Code with amendments, additions, or deletions as the Michigan Department of Energy, Labor and Economic Growth determines appropriate. The Code became effective statewide on July 31, 2001. The State Construction Code provides for statewide uniformity of application and implementation of rules governing the construction, use, and occupancy of buildings and structures. (Prior to the 1999 PA 245 amendment, communities had the option of adopting the State Construction Code – which was the National Building Officials and Code Administrators [BOCA] Code with State amendments – or they could adopt any other nationally recognized building code such as the Uniform Building Code [UBC] or the Council of American Building Officials [CABO] Code for one and two family dwellings. Approximately 40% of Michigan communities adopted the State Construction Code and 50% followed the National BOCA Code. The remaining 10% adopted the UBC.)

Provisions of the State Construction Code and other building codes are enforced through authorized local building inspection agencies and state inspectors. In Michigan, there are 2,600 registered local inspectors and 80 state inspectors. In communities where comprehensive planning is not done, the building code is often the only land use regulatory measure available.

Building codes, used in concert with other available land use / development guidance measures, can be effective in reducing or eliminating damage caused by many types of hazards such as high winds, fire and flooding. For example, proper adherence to wind load requirements for roof systems can substantially reduce damage to structures from straight-line and tornadic winds. By securing the "envelope" of a structure, water-related damage from rainfall can also be greatly reduced. Many times, that makes the difference between a home that suffers minimal or no damage and one that suffers major damage or is a total loss.

For residential structures within the floodplain, the new State Construction Code requires that the structure have the lowest floor one foot above the base flood elevation (the depth of peak elevation of flooding, including wave height, which has a 1% or greater chance of being equaled or exceeded in any given year – commonly known as the "100-year flood.") This is called the "design flood elevation." Basements (defined as being below grade on all sides) must be at or above the base flood elevation. Though not a stringent as Michigan's previous State Construction Code (which required that the lowest portion of all horizontal structural members supporting floors – such as floor joists – be located at or above the 100-year flood elevation, effectively providing a one-foot "freeboard"), the new Code still provides protection against significant flood damage in many cases.

The Code also requires that utilities and mechanical equipment be elevated above the 100-year flood elevation or protected so as to prevent water from entering or accumulating within the components during the occurrence of a 100-year flood.

For non-residential structures, the level of flood protection required by the State Construction Code is dependent on the classification of the building use. Category III and IV buildings (critical facilities) such as hospitals, emergency response facilities, power generation stations and other public utilities, must have the lowest flood elevated or dry flood proofed one foot above the 500-year flood elevation. Buildings that do not fall within Category III or IV must have the lowest floor elevated or flood proofed one foot above the 100-year flood elevation. (A listing of Category III and IV buildings may be found in the publication "American Society of Civil Engineers Flood Resistant Design and Construction – SEI/ASCE 24-98.") Non-residential buildings using the watertight flood-proofing option must be designed and certified by a registered architect or professional engineer.

By enforcing the flood resistant construction provisions of the State Construction Code, inspectors can help ensure that new construction within flood prone areas will be built in such a manner as to minimize future flood losses.

The State of Michigan has taken a number of steps to increase the effectiveness of Building Code enforcement by targeting both state and local building code Inspectors. 1986 PA 54, the Building Officials Registration Act, requires all building inspectors to be registered with the State and continue training throughout their careers. Training sessions conducted by the Bureau of Construction Codes, Department of Energy, Labor and Economic Growth, are required for all building code Inspectors every three years in order to be registered with the State. Michigan Department of Environmental Quality personnel also participate in these training sessions to provide information relating to floodplain management, the NFIP, and the MDEQ permit requirements. The training sessions make the inspectors aware of the Code requirements related to flooding and are an important phase of flood hazard mitigation. Because of the continual turnover in the number of building officials, there is a need to foster an ongoing education program. The local building officials are an essential component of the effort to ensure that future development is not flood prone.

Following the training sessions, evaluations are given in order to set high standards for the quality of building inspectors in Michigan. The Bureau of Construction Codes also evaluates the performance of a community's building inspection and enforcement effort. These performance evaluations are usually done when a community requests an audit, or a complaint is filed by a private citizen.

At the national level, the Insurance Services Office (ISO) has undertaken a major initiative designed to foster better building code enforcement. Under the ISO's Building Code Effectiveness Grading Schedule – part of the insurance industry's continuing efforts to reduce natural hazard damage – local building departments will be "graded" on their code enforcement efforts. A community's grade will be determined by the resources devoted to code enforcement activities. Communities that have good codes and code enforcement programs in place will receive a higher grade than those communities that don't, and property owners in the higher-graded communities will be rewarded with homeowners' insurance premium credits. The ISO plans to inspect every building department in the country.

The ISO developed the Grading Schedule after determining that much of the construction failure resulting from natural disasters was due, in large part, from the construction not being built to comply with codes. The insurance industry's experience has shown that communities with effective codes and code enforcement have a more favorable (lower) insurance loss experience because they have less disaster-related damage to structures. The Building Code Effectiveness Grading Schedule is modeled after a similar and long-standing ISO fire-grading program, which assesses local fire departments and water supplies. From a practical standpoint, implementation of this initiative in Michigan will mean better local codes and code enforcement, which should in turn reduce disaster-related structural damage and disaster costs.

Subdivision Regulations

Subdivision regulations are the legally established standards of design and construction for dividing a land parcel into smaller ones for the purpose of selling or leasing the property**.** The Land Division Act (1967 PA 288, as amended by 1996 PA 591, 1997 PA 87, and 2004 PA 524) governs the subdivision of land in Michigan. The Act requires that the land being subdivided be suitable for building sites and public improvements, that there be adequate drainage and proper ingress and egress to lots, and that reviews be conducted at the local, county and state levels to ensure that the land being subdivided is suitable for development. The Act also requires conformance with all local planning codes. From a hazard mitigation standpoint, that point is important because it gives the local planning commission the authority to approve subdivision development in accordance with the local comprehensive plan and regulatory standards.

In terms of process, the subdivision of land has three major phases. The first involves a preliminary review of the engineering aspects of the project – roads, drainage, utilities, and other necessary services, by local and county reviewing agencies. The second phase involves a review of the proposal by the Michigan Department of Environmental Quality, the Michigan Department of Transportation, and the Michigan Department of Energy, Labor and Economic Growth to ensure compliance with state standards regarding location and engineering. At the end of this phase, the developer can obtain tentative approval from the local governing body of the jurisdiction in which the project is located. The final phase involves preparation of the final plat or map of the subdivision. Local and state

reviewing agencies again review the final design to ensure compliance with local and state standards. Once approved, the plat is registered with the county register of deeds.

Subdivision regulations can be an effective tool in reducing risk and vulnerability to certain hazards, such as flooding and wildfires, if mitigation factors are incorporated into the subdivision process through mechanisms such as local planning codes. For example, a community may allow a subdivision to be placed in a heavily wooded area susceptible to wildfire if proper engineering measures are taken regarding lot size and ingress and egress, thereby providing a basic level of protection to developed home sites and the residents occupying those home sites.

From a flood hazards viewpoint, proposed subdivisions are reviewed by the County Drain Commissioner for proper drainage, and for floodplain impacts by the Michigan Department of Environmental Quality / Land and Water Management Division. (Refer to the Riverine Flooding chapter of the Michigan Hazard Analysis section in the MHMP for specific MDEQ provisions that directly address flood mitigation.)

Like any regulation, the Land Division Act can be effective if it is enforced and coordinated with other land use / development mechanisms in an effort to reduce overall community risk and vulnerability to hazards.

The subdivision rules relating to flooding are implemented through a review process and use of restrictive deed covenants. However, the restrictive deed covenants that are filed under the Act are only effective if the local building official is aware of and enforces the restrictions. Continuing education for the local building officials is essential for effective implementation of the Act.

The rules currently allow the construction of basements below the 100-year flood elevation, but these basements must be flood proofed, or it must be demonstrated by an engineering analysis that the basement will not be adversely impacted by hydrostatic pressures exerted by floodwaters. The developer must also obtain a letter of map revision (LOMR) from FEMA, certifying that the property has been filled above the 100-year flood elevation and the soil has been properly compacted. The LOMR officially removes the property from the 100-year floodplain.

The design standards for a flood proofed basement are fairly involved. Unless the building official is aware of the restrictive deed covenants and the design standards, and is enforcing these requirements, there is considerable potential for flood damage to basements even in subdivisions platted under the current act. Thus, as noted earlier, continuing education is essential.

It should be noted that Michigan's subdivision regulations are under continual attack by home builders and developers as being too restrictive. If the regulations are reduced in the future, the potential for future flood damages will be increased considerably.

Special Area, Use and Design Regulations

Examples of special area, use and design regulations include:

- Local floodplain management ordinances;
- Coastal zone management regulations;
- Watershed management regulations;
- Special infrastructure design standards and regulations;
- Drainage regulations;
- Housing regulations;
- Wetland protection regulations;
- Natural rivers protection regulations;
- Farmland and open space protection regulations;
- Endangered species / habitat regulations; and
- Historic preservation regulations (among many others).

These regulations (most of which are administered by a state or federal agency in cooperation with local officials) are designed to regulate a certain aspect of the natural or built environment to ensure protection of the public health, safety

and welfare, or some significant or unique natural feature. Not surprisingly, most of the regulations have goals that are remarkably similar to those of hazard mitigation. They provide valuable mechanisms for achieving mitigation objectives. These regulations are discussed in greater detail in the following sections of this plan.

To be effective, the provisions of these special regulations must be fully integrated into the comprehensive planning process at the local level. Major provisions of pertinent regulations must be included or addressed in the comprehensive plan and primary implementing mechanisms such as the zoning ordinance, capital improvements plan, etc. In addition, state agencies administering the regulations must coordinate development-related actions so that one agency's work does not conflict with those of another agency.

Two programs administered by the State of Michigan provide good examples of special area / use measures that, while originally designed to accomplish something else, also contribute to a reduction in a community's risk and vulnerability to hazards (flooding and wildfires in these two instances):

Natural Rivers Program

This program, administered by the Michigan Department of Environmental Quality, seeks to establish a system of outstanding rivers in Michigan and to preserve, protect and enhance their wildlife, fisheries, scenic, historical, recreational and other values. Through the natural rivers designation process, a natural river district is established and a zoning ordinance is adopted. Within the natural river district, permits are required for building construction, land alteration, platting of lots, cutting of vegetation, and bridge construction. Not all of the zoning ordinances on the natural rivers have the same requirements, although they all have building setback requirements and vegetative strip requirements.

Although not specifically designed to reduce flood losses, the program nonetheless has flood hazard mitigation benefits by requiring building to be constructed away from the river and out of the floodplain. The program is very effective when administered as intended. Like any regulatory program, if the administrator and the variance board are aware of the requirements of the program and their duties, it is very effective.

Farmland and Open Space Preservation Program

This program, administered by the Michigan Department of Agriculture and Rural Development, has the primary goal of preserving unique and beneficial open space. It does this by transferring development rights and acquiring easements. There are two categories of land eligible. The first category makes up historic, riverfront, and shoreland areas. The second category includes land that conserves natural or scenic resources, enhances recreational opportunities, promotes the conservation of soils, wetlands and beaches, or preserves historic sites and idle farmland.

The largest component of the program provides landowners with an opportunity to get a break on their property taxes for designating parcels of land that will remain undeveloped. Thus, this mechanism could be used to reduce risk and vulnerability to wildfires by preventing development in heavily forested areas. It could also reduce vulnerability to flooding by preventing development along rivers and in floodplains. However, the program does have a drawback in that the agreements are not in perpetuity and may be relinquished under certain circumstances. The land can be removed from the program under certain circumstances, with the payment of a penalty. Over the short-term, the program is very effective at slowing the development of the special open spaces. It does not, however, necessarily eliminate future development on the parcels and therefore should not be considered an effective long-term mitigation tool. However, there is also a Purchase of Development Rights program, which does purchase development rights in perpetuity. In addition, there have been significant donations of development rights to the State and to local conservation programs.

Capital Improvements Planning

A Capital Improvements Plan (CIP) is the mechanism through which a community identifies, prioritizes, and establishes financing methods for needed public improvements such as new or improved public buildings, roads, bridges, treatment plants, water and sewer infrastructure, etc. Under Michigan law, planning commissions are required to annually prepare and adopt a CIP and recommend it to the legislative body for their use in considering public works projects. Generally, public improvements included in the CIP are those that require a substantial expenditure of public funds. (Each jurisdiction must decide what constitutes a substantial expenditure.) The CIP can be an effective implementing mechanism for the community's comprehensive plan and zoning ordinance because it dictates the nature

and timing of public facility expenditures. Normally, the CIP is established for a six-year period. The first year of the CIP becomes the year's capital budget and is the basis for making appropriations for capital improvements. As a result, the annually approved items are the highest priority public improvements to be built in planned areas.

For the CIP to be an effective mechanism for implementing the comprehensive plan and zoning ordinance, public improvements must be targeted for those areas of the community where growth or certain types of land uses are desirable. Public improvements should not be put in those areas where growth or development is not desired. In that sense, the CIP should mirror the comprehensive plan and zoning ordinance; otherwise, the three mechanisms may work against each other (i.e., public expenditures in a non-desirable area may spur unwanted development). On the other hand, if desirable private development occurs or is proposed, the CIP may have to be adjusted somewhat to coordinate public investment with the desired private development. Each year, the planning commission must extend the CIP one more year through the established local planning process. As part of that process, the commission will reevaluate project proposals in light of any developmental changes that might necessitate revision in public improvement priorities. Each year, then, becomes the beginning of a new CIP.

From a hazard mitigation perspective, the CIP, if coordinated with the community's comprehensive plan and zoning ordinance, can be an effective mechanism for creating a desirable, less vulnerable land use and development pattern. Planning commissions, because they create and adopt each of the three mechanisms, are instrumental in ensuring that public investment is done in such a way that it helps reduce or eliminate the community's risk and vulnerability to hazards.

Other Considerations: Local Mitigation Policies, Programs, and Capabilities

Local jurisdictions vary widely in the number and experience of staff that are, or can be, devoted to hazard mitigation activities. All counties are represented by Emergency Management Coordinators who handle emergency response activities, exercises, response planning, and related duties, and these persons are involved in hazard mitigation planning activities, hazard mitigation project grant applications, monitoring the implementation of local hazard mitigation activities, and promoting the hazard mitigation concept within their communities (and sometimes beyond).

Unfortunately, some jurisdictions seem to have a frequent turnover of emergency management staff. While this has been one of the reasons why the development of a local hazard mitigation plan is helpful (information acquired by one person can be easily passed on to his or her replacement in the form of a printed document), nevertheless it can remain a significant problem for some jurisdictions when new emergency management staff enters and needs to take the time to become familiarized with existing conditions, information, relevant agency contacts, policies, forms, procedures, equipment, existing resources, interagency agreements, mutual assistance arrangements, and so on. Some communities may not be fully aware of the great number of things that a good emergency management coordinator needs to keep track of or be able to accomplish, with very short notice. Some communities have provided only minimal staff time and resource commitment to their emergency management programs. In some cases, a quarter time position is all that has been arranged, and serious consideration should be given to the expansion of emergency management staffing and staff hours.

In some areas of the State, local sentiments reveal a mistrust of higher levels of government. In some cases, there is suspicion that the acceptance of federal funding will come "with strings attached" that will cause the loss of some aspect of local authority to State or Federal officials or agencies. Emergency management coordinators tend to be aware of various local needs that can be supplemented with State and Federal assistance, but sometimes must accept the decisions of local officials who may be reluctant to admit any vulnerabilities or community preparedness weaknesses. If fundamental preparedness issues are sometimes difficult for local emergency managers to explain and "sell" to their community decision-makers, then preventive actions such hazard mitigation planning and projects can be perceived as even harder to successfully explain and promote under such circumstances. This trend is evidently not a broadly generalizable condition, since Keweenaw County, the smallest in population and one of the smaller counties in land area, contained some of the most enthusiastic proponents of hazard mitigation planning and one of the swiftest mobilizations of support for the process. At the other end of the state, many jurisdictions in the Metropolitan Detroit area were also very enthusiastic and efficient in their planning activities. Similarly, areas of differing degrees of urbanization and population density, and with different types of land uses and economies throughout the state have shown a good responsiveness to hazard mitigation planning initiatives and their requests for project grant funds. Variation in the extent and effectiveness of support for hazard mitigation activities appears to me more related to the

circumstances of local agencies and officials than it is to general attributes such as regional location, population size and density, wealth or economic specializations.

Most local programs have in some way utilized available State and Federal grant funds, or at least submitted applications at some point requesting the use of such funds. Attachment C provides detailed listings of the history of funding that has been directed toward hazard mitigation activities. The following table has been newly updated to summarize the hazard mitigation funds that have contributed to activities in specific jurisdictions (counties) throughout the state.

MITIGATION PROJECT FUNDING MADE AVAILABLE IN MICHIGAN SINCE 1994, BY COUNTY (AS OF MAY 2013)

COUNTY	PROJECT TOTAL	FEDERAL SHARE
Alcona	$ 297,992	$ 180,000
Allegan	$ 413,235	$ 308,607
Alpena	$ 566,540	$ 367,088
Antrim	$ 447,511	$ 286,258
Arenac	$ 215,840	$ 127,875
Baraga	$ 78,702	$ 56,255
Barry	$ 332,795	$ 248,413
Bay	$ 3,083,644	$ 2,467,959
Cass	$ 87,520	$ 60,540
Charlevoix	$ 432,579	$ 301,456
Cheboygan	$ 17,876	$ 13,407
Chippewa	$ 566,652	$ 424,989
Crawford	$ 1,967	$ 1,475
Delta	$ 12,575	$ 9,432
Dickinson	$ 84,701	$ 63,297
Eaton	$ 320,086	$ 225,000
Emmet	$ 142,955	$ 56,436
Genesee	$ 4,956,999	$ 3,719,810
Gogebic	$ 609,918	$ 330,089
Grand Traverse	$ 76,989	$ 57,742
Gratiot	$ 405,181	$ 277,352
Houghton	$ 651,742	$ 478,846
Huron	$ 587,630	$ 376,500
Ingham	$ 1,950,331	$ 1,439,293
Ionia	$ 399,372	$ 298,243
Iosco	$ 154,696	$ 67,511
Iron	$ 209,825	$ 148,742
Isabella	$ 58,744	$ 44,059
Jackson	$ 107,637	$ 76,797
Kalamazoo	$ 84,318	$ 63,239
Kent	$ 8,877,038	$ 6,455,211
Keweenaw	$ 150,652	$ 112,500
Lake	$ 27,940	$ 20,000
Lapeer	$ 5,421	$ 4,066
Leelanau	$ 21,975	$ 13,875
Lenawee	$ 147,448	$ 110,586
Livingston	$ 590,470	$ 442,852
Mackinac	$ 273,754	$ 183,750
Macomb	$ 2,374,738	$ 1,376,530
Marquette	$ 2,130,426	$ 1,313,288

Mason	$	27,940	$	20,000
Mecosta	$	109,965	$	109,965
Midland	$	84,056	$	58,637
Monroe	$	1,642,496	$	1,318,570
Muskegon	$	343,898	$	257,923
Newaygo	$	18,638	$	12,000
Oakland	$	3,826,141	$	2,544,356
Ogemaw	$	202,325	$	150,000
Ontonagon	$	64,811	$	48,379
Osceola	$	27,940	$	20,000
Otsego	$	2,106	$	1,575
Ottawa	$	4,303,289	$	3,083,578
Saginaw	$	4,060,032	$	2,664,727
Sanilac	$	615,471	$	375,316
St. Clair	$	356,259	$	267,195
St. Joseph	$	327,175	$	245,381
Tuscola	$	4,010,683	$	2,592,157
Van Buren	$	480,292	$	316,635
Washtenaw	$	536,155	$	402,116
Wayne	$	4,931,743	$	3,633,023
Wexford	$	846,431	$	634,823
Statewide (other)	$	1,246,019	$	827,041
TOTAL in Michigan	$	60,020,279	$	42,192,768

- The totals in this table represent 269 separate project grants. Two-hundred-fifty-six (256) of the projects are complete and the totals included in the table are based actual project costs. For the thirteen (13) grants that were awarded but not yet complete as of May 2013, projected totals were used based on grant application budgets.
- This table includes totals from two multi-county projects that benefitted a total of seven counties. The completed project totals for those two projects were evenly distributed to the counties they benefitted.
- There were a total of twelve projects that yielded benefits that were statewide or regional in nature. Those twelve projects are totaled under the category of "Statewide (other)".
- The project grant totals represented in this table are from grants awarded to the State of Michigan from the Federal Emergency Management Agency (FEMA). The grants were awarded four of FEMA's five separate grant programs that are collectively known as Hazard Mitigation Assistance (HMA). The four grant programs represented in this table are the Hazard Mitigation Grant Program (HMGP), the Flood Mitigation Assistance (FMA) program, the Pre-Disaster Mitigation (PDM) program, and the Repetitive Flood Claims (RFC) program. All grants, other than totaled in the "Statewide (other)" category, were passed through from the State of Michigan to local units of government.

As can be seen from this table, and from the information in Attachment C, the use of hazard mitigation funds to support specific projects has been widespread throughout the state, and has been quite balanced so as not to unduly favor any particular regions or jurisdictions. Some areas may have received lighter funding due to cases (described previously) in which local authorities have been reluctant to authorize the application for and acceptance of State and Federal dollars. For every case in which that may have happened, some comparable case can readily be found in which an adjacent county that was economically, demographically, and geographically similar has been more active in applying for, and receiving, funds for hazard mitigation projects. In other cases, such an interpretation may be misleading, in that such projects are meant to address specific vulnerabilities that other communities may not have. Therefore, a lack of funding may only indicate that a community has a lesser need to make use of such funds, or that the types of projects preferred by the community are of a nature that has difficulty matching with the types of projects that are currently eligible under State and Federal funding sources. (For example, if a community has a problem with aging dams, there are no clear means to obtain funding for dam maintenance projects from available programs.)

Another issue that arises in many communities is the lack of a clear means by which to assemble the local match requirements for most federal sources of funding. For most communities, a cash match is out of the question, and even with the acceptability of "soft matches," there remain problems with assembling (and documenting) all of the qualifying services that could add up to the match value for a project of substantial expense. Since the State of Michigan has not been providing any matching funds for the non-federal share, it tends to fall upon local grant applicants to determine what sources of matching funds are possible, and then to shoulder the substantial administrative burden of documenting match items, which can be very difficult for a complicated or expensive project.

Climate Change Considerations

In 2010 MSP/EMHSD planning staff participated in multiple activities to assess the effects that climate change might have on Michigan's hazards. These activities included a set of meetings and communications coordinated by the Michigan Department of Community Health, and attendance at the MSU Climate Change Symposium in East Lansing, on April 26 and 27. The MDCH meetings were the start of a year-long multi-agency planning effort to identify and assess the potential impacts of climate change upon public health. Participants identified numerous areas of overlap between Climate Change topics and the types of hazards that are assessed in this plan. For example, climate change can eventually exacerbate the severity of thunderstorms, severe winds, extreme temperatures, flooding, drought, erosion, wildfires, and invasive species. Climate change issues also tie in with the problems of infrastructure failures and public health emergencies. Consideration was given to the addition of a new section in this plan, to address climate change issues, but it was decided that the topic was best covered by referring to climate change in the appropriate sections that deal with the specific hazards that may be exacerbated. This content has been substantially expanded in the 2014 update of this plan, as information about climate change effects is gathered from various sources and its nature becomes clearer. From an emergency management and emergency planning perspective, the climate change issue seems to be easiest to handle in terms of the specific hazards (already described in this plan) through which its effects are known. Certain indicators of climate change are already present. For example, in Michigan's daily record temperatures, heat records outnumbered cold records by 3 to 1 during the 1990s, and by 6 to 1 during the 2000s. Long-term planning and mitigation is being undertaken by other agencies that deal specifically with long-term environmental and ecological issues, and the MSP/EMHSD has continued to coordinate with them agencies about the climate change issue, becoming an active member of the Michigan Climate Coalition as part of its coordination and outreach on the subject.

Michigan Land Use Policy: Governor's Land Use Leadership Council of 2003

In February 2003, Governor Granholm, supported by bipartisan leadership from the Michigan Legislature, created the 26-member Michigan Land Use Leadership Council (MLULC) to develop recommendations for charting the course of Michigan's future land use policy. Specifically, the MLULC was given the responsibility to find ways to minimize the negative impacts of current and projected land use patterns on Michigan's environment and economy. The MLULC represented a broad spectrum of stakeholders (representing governmental, private sector, and private-nonprofit entities) concerned and knowledgeable about Michigan's land use policy, laws, regulations, and trends.

For a six-month period in 2003, the MLULC studied dozens of complex and often controversial land use and land development issues. The MLULC held six public hearings during that six-month period and a total of 398 individuals provided oral testimony. In addition, 1,330 written or e-mail comments were received for consideration by the MLULC. One of those written responses was developed by the Michigan Hazard Mitigation Coordinating Council (MHMCC), which submitted a three-page letter urging the MLULC to consider a consolidation of the State's three separate planning and zoning enabling laws into a single, coordinated enabling law that also addresses hazard vulnerability reduction as a required planning element in all land use (comprehensive) plans and land use change decisions. The MHMCC letter even offered specific language that could be incorporated into the new statute. The ultimate goal of the MHMCC effort was to institutionalize hazard vulnerability reduction into the land use and land development structures at the state, regional, and local levels of government.

In August 2003, the MLULC issued its final report which contained more than 160 recommendations for Michigan land use policy reforms. Although the MLULC report does not specifically mention the MHMCC's recommendations per se, this was not totally unexpected since the Council's recommendations were not sent to the MLULC until late in its comment period. However, the MLULC final report clearly espouses the creation of *sustainable* communities in Michigan, which fits hand-in-glove with the basic hazard mitigation goal of creating sustainable, disaster resistant communities. To that end, the MLULC final report advocates several general land use measures that also support the basic hazard mitigation principles of sustainability and disaster resistance.

Policies that Aid in Reducing Flood Vulnerability

In Chapter 5, the MLULC report discusses the need to "explain the role and value of wetland, natural river, and sand dune protection and other state environment land use programs in protecting and enhancing natural environments." This recommendation, while aimed primarily at environmental protection, has the additional benefit of mitigating flooding and Great Lakes shoreline erosion – two of Michigan's top natural hazards. Chapter 5 also advocates the creation of "Agricultural Production Areas" under Michigan's PA 116 farmland preservation program to minimize the encroachment of development on valuable agricultural lands. This measure would also have the added benefit of mitigating potential flooding, since many farms border rivers and drains that frequently flood. Agricultural land is a much more desirable land use bordering rivers and drains (because of its ability to serve as a "sponge" to absorb floodwaters) than would be residential housing or commercial development (which could be damaged by flood waters). In addition, Chapter 5 advocates the expansion of the State's Conservation Reserve Enhancement Program (CREP), which pays farmers to establish and maintain buffer strips along watercourses. The CREP also supports hazard mitigation by keeping areas adjoining watercourses open and free of development, thereby reducing potential flood losses.

Chapter 5 also recommends measures to prioritize Great Lakes shoreline protection measures, preserve critical headwaters areas through land or land rights acquisition, revise and streamline the Land Division Act, encourage greater participation in several land conservation programs, and create a clearinghouse for various land protection grant programs. All of these recommended measures have the added benefit of potentially aiding in the mitigation of flooding and other natural hazards.

Improving Land Use Planning and Land Development Policies

Chapter 6 of the MLULC final report recommends measures that address land use planning and land development in Michigan. Again, several of these measures have the added benefit of supporting basic hazard mitigation principles. For example, Chapter 6 advocates an expansion of land use education for local planning and zoning officials, local elected officials, and possibly even teachers through intermediate school districts. If this land use education also included elements pertaining to hazard mitigation and its relationship to land use planning and land development, it would be consistent with and fully support similar objectives found in the Michigan Hazard Mitigation Plan. Chapter 6 also advocates the inclusion of storm water retention in improved road corridors (which can help reduce flooding of adjacent properties), and studying the negative impacts of impervious surfaces on both urban and rural watersheds. The latter objective is consistent with two objectives in the Michigan Hazard Mitigation Plan that seek to institute enhanced watershed planning and decision making, and to study land character and its influence on storm water runoff.

Perhaps most importantly, Chapter 6 of the MLULC final report discusses the need to modernize Michigan's antiquated planning and zoning enabling laws. Again, this is consistent with and supports several objectives in the Michigan Hazard Mitigation Plan and was the primary subject of the Council's 2003 letter to the MLULC. Fortunately, the effort was successful and resulted in the enactment of the Michigan Zoning Enabling Act, 2006 PA 110, which took effect on July 1, 2006. (Note: 2006 PA 110 was subsequently amended on February 29, 2008, by 2008 PA 12 to make several needed "corrective amendments" to various administrative mechanisms and processes contained in the original act. In addition, at the time of this writing, a bill to unify and amend Michigan's three planning enabling acts into a single, coordinated planning act had been presented to Governor Granholm for her signature.)

Chapter 6 also discusses the desirability of enhanced governmental cooperation at the regional level for land use planning and decision making – specifically recommending the preparation of regional emergency preparedness plans. If that recommendation is adopted, there is a real opportunity for the Council to advocate for the inclusion of hazard mitigation as an essential element of that larger emergency preparedness plan. In addition, Chapter 6 recommends that special assessment districts or adequate public facilities ordinances be authorized to allow for provision of, among other things, adequate storm drain infrastructure in new developments. This provision, if instituted statewide, could greatly reduce future flooding risks.

Reducing the Vulnerability of Infrastructure

Chapter 7 of the report addresses a variety of infrastructure issues. One recommendation in particular – the desirability of burying electrical and telecommunications lines – has hazard mitigation implications in that buried lines are much

less vulnerable to damage caused by natural forces such as wind, lightning, ice and snow, and severe storms. This recommendation is also consistent with and supports a similar objective in the Michigan Hazard Mitigation Plan.

These examples highlight the many commonalities that the MLULC report and the Michigan Hazard Mitigation Plan share. The MSP/EMHSD and the MCCERCC will work with the Governor's office and other involved agencies and organizations (as time, resources, and circumstances allow) in implementing those elements of the MLULC report that address hazard mitigation and will ultimately aid in reducing Michigan's risk and vulnerability to natural, technological and human-related hazards.

Implementation of MLULC Report Recommendations

To date, progress on the 160 MLULC final report recommendations has been slow but steady. At the time of this writing, over 30 recommendations had either been fully or partially addressed and another 30 were in progress of being implemented. One of the early successes in this effort was the consolidation of the State's three antiquated zoning enabling laws into a single, comprehensive law known as the Michigan Zoning Enabling Act (2006 PA 110, effective July 1, 2006). The new Zoning Enabling Act provides a more modern framework and process for using zoning as an effective regulatory tool to guide land use and development. This had been one of the more important objectives contained in the 2005 edition of the Michigan Hazard Mitigation Plan. The Michigan Zoning Enabling Act is a major step forward in the effort to further institutionalize natural hazard risk and vulnerability reduction into land use and land development decision making processes. (Note: A companion effort to unify and modernize Michigan's three planning enabling laws had been presented to Governor Granholm on March 6, 2008 for signature into law. At the time of this writing, no action had been taken by the Governor on the bill.)

Existing Hazard-Specific Mitigation Measures

Mitigation is occurring in many facets of Michigan state government, local government, and private industry. Mitigation can be found in many laws, programs and initiatives already being implemented on a daily basis – although it may not specifically be called hazard mitigation. Even though hazard mitigation may not be the expressed purpose of the law, program or initiative, the efforts often eliminate or reduce hazard risk and vulnerability. Each hazard section of the Michigan Hazard Analysis (MSP/EMHSD Publication 103) provides an overview of the laws, programs and initiatives in effect in Michigan and elsewhere that have (or could have) a mitigating impact on the hazards facingMichigan communities. (For brevity purposes, those laws, programs and initiatives will not be repeated here. Refer to the Michigan Hazard Analysis for a complete listing.)

Following are synopses of the overall effectiveness of existing laws, programs, policies and initiatives for the hazards deemed most problematic in Michigan. Where applicable, suggestions have been made for ways to make the measure more beneficial in reducing long-term hazard risk and vulnerability. Those suggestions have then been translated into specific objectives and action items for short-term and/or long-term implementation by the Michigan Citizen-Community Emergency Response Coordinating Council (MCCERCC), working in partnership with other appropriate entities. Refer to the Mitigation Opportunities, Recommendations, and Implementation section.

Riverine Flooding

Measures taken to reduce the State's risk and vulnerability to flooding have been primarily non-structural with a focus on discouraging floodplain occupation and improving building code enforcement. In addition, an emphasis on the regulation and management of land adjacent to a river is seen in many of the laws and programs administered by the State. A culmination of efforts has resulted in a generally positive trend towards riverine flood mitigation. In evaluating the effectiveness of the measures being initiated at the state level, a discussion of the local governing process has to be included. Because so much of the success of state level programs and initiatives relies on the cooperation of and coordination with local government, an evaluation of state government effectiveness cannot be void of local government actions.

Floodplain Regulatory Authority

The Floodplain Regulatory Authority found in Part 31, Water Resources Protection of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended, is the primary state regulation that deals with construction within floodplains, and is effective at maintaining the flow carrying capacity of a watercourse for those projects that are permitted. The "harmful increase" phrase used in the rules is flexible enough to allow reasonable development within the riverine floodplain without increasing flood damages.

The Act is also effective at prohibiting the construction of new residential structures within the floodway. However, there are areas of concern related to the Act:

Small Watersheds. The Act only deals with watercourses that have a drainage area greater than two square miles. There are many flooding problems on smaller watercourses that do not fall under the authority of the Act, which must be administered at the local level. Some communities are very effective at regulating the floodplains of the smaller watersheds, but to many communities floodplain regulation does not rate high on the priority list of things to do.

Inland Lake Floodplains. The Act does require a permit for filling or construction within the floodplain of inland lakes. The local building code would also require elevating structures in lake floodplains. However, if the floodplain of the lake is not identified by a floodplain map, the local building official may not be aware of the flooding potential and may not require adequate elevation.

Education Regarding Permit Requirements. There is still a need to continually make building officials and property owners aware of the need for a permit from the MDEQ under Part 31. A common response from a property owner is, "I did not know I needed a permit for building in the floodplain." It is difficult to determine the amount of construction that is occurring in the floodplain without benefit of a MDEQ permit, although it is happening on a regular basis. The more informed local building officials are regarding the requirements, the greater the compliance. There is a continuing need to educate both the public and local officials on state permitting requirements.

Structures Occupying Floodways. The Act is quite specific about prohibiting the residential occupation of the floodway. However, there are many existing structures within floodways of Michigan rivers. These structures are "grandfathered in," using the current interpretation of Part 31. A structure in the floodway can be remodeled, as long as the size of the structure is not increased. Thus, the occupation can remain in the floodway indefinitely. From a flood hazard point of view, this policy should be reviewed. An Attorney General's opinion may be needed on the floodway occupation issue for clarification of this policy.

Education of Building Officials. For buildings constructed in a filled portion of a floodplain, Part 31 has specific requirements to ensure that the building will not be damaged by floodwaters. However, the effectiveness of these requirements is dependent upon the awareness of the local building officials. Again, the education of building officials is essential to the reduction of future flood losses.

Flood Storage. "Critical" flood storage has been evaluated in only a few areas of the state. A critical flood storage area is determined based on an engineering analysis of the impact that the elimination of floodplain storage would have on downstream flood stages. The loss of flood storage in a "critical" area would result in increased flood discharges and stages in the downstream areas. To help combat this problem, in 2000 the MDEQ implemented a requirement for compensating cut for all floodplain fills statewide, except for projects involving less than 300 cubic yards of floodplain fill.

At both the state and national level, very little has been done to determine the long-term effects of the elimination of floodplain storage areas. There is a need to continue to identify critical storage areas within the state.

Floodplains Not Mapped. Part 31 applies to all riverine floodplains having a watershed greater than two square miles. However, not all of the floodplains in the state have been mapped under the NFIP. This causes considerable confusion among local officials and property owners. There is a common misconception that "if a floodplain is not identified on a map published by FEMA, then there are no state floodplain permits required." There is a continuing need to educate both the public and local officials on state permitting requirements.

In addition to unmapped communities, the accuracy and delineation of many mapped floodplains is subject to continuing debate. The existing federal floodplain mapping program is inadequate in its current state and form. For that reason, FEMA is undertaking a nationwide map modernization initiative to map all communities in the nation and produce updated digitized flood maps. The MDEQ has implemented a statewide floodplain mapping business plan to complement and supplement the federal map modernization program.

Stormwater Management. There is currently no state law that regulates stormwater runoff quantity. Any regulation that exists is done at the local/county level. As a result, there is a wide variety of requirements across the state. There is a growing awareness of the need for stormwater management on a "watershed" basis, although a statewide approach will not likely occur in the near future. The MDEQ has prepared a stormwater management best management practices guidebook to assist local governments in their stormwater management efforts.

Building Codes
See Existing Mitigation Tools and Measures, Effectiveness of Land Use / Development Measures – Building Codes.

Subdivision Regulations
See Existing Mitigation Tools and Measures, Effectiveness of Land Use / Development Measures – Subdivision Regulations.

Inland Lakes and Streams, Part 301 of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended
The Act is reasonably effective for what it was enacted to do – that is, regulate construction, excavation, and commercial marina operations on the State's inland waters, and to protect the "public trust."

From a flood hazard perspective, the Act discourages lengthy stream enclosures and extensive filling below the ordinary high water mark, which helps to maintain the flow carrying capacity of a watercourse. Since the Act applies to all watercourses that have a defined bed and bank, there are no drainage area limitations. This provides the MDEQ some input to watercourse alterations, even if the drainage area is less than two square miles.

Dam Safety Program, Part 315 of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended
The Dam Safety Act provides review and inspection requirements for dams, along with emergency action plans for "high" and "significant" hazard dams. The Act provides the necessary means for adequately regulating dam safety, provided adequate staffing levels are maintained. The Act will not prevent dam failures. However, it will help to reduce the chance of and potential impacts of a dam failure.

There are no laws that regulate development downstream of a dam. Existing floodplain, subdivision, and NFIP requirements provide no consideration for a dam failure. However, the flood elevations that can result from a dam failure are significantly higher than would be shown in an existing flood insurance study or a typical floodplain determination. Development can take place downstream of a dam, which could be destroyed in the event of a dam failure. In fact, a dam that was initially classified as a low hazard dam could be reclassified as a high hazard dam as development occurs downstream.

In some states, development is regulated downstream of dams, as consideration is given to the possibility of failure of the dam. Currently, Michigan does not have any requirements relating to development in the hydraulic "shadow" of a dam.

Floodplain Service Program
The Floodplain Service Program is provided by the MDEQ to the public without the assessment of a fee. The service is very effective in that it provides floodplain information and permitting requirements before plans are finalized and building begins. As a result, informed decisions can be made which can result in lower future flood damages.

Because the program is not funded by fees, and there are no statutory timeframes imposed, the service is unfortunately not a high priority item. The primary focus of the staff is on processing the permits. Whatever staff time is left over is used to provide services. As a result, during the peak permitting season, it is possible that some service requests will not receive a prompt response. In addition, if this service were widely publicized, staff would likely be overwhelmed with requests. Possible (though unlikely) remedies could include fees (which would likely discourage service requests and defeat the purpose of the service), or additional staff (which is unlikely given continuous budget constraints).

National Flood Insurance Program
The NFIP has provided a needed stimulus for state and local officials to focus on floodplain management. The benefits and drawbacks of the NFIP have been discussed for years, and it is not the intent of this plan to reiterate those discussions.

Community Assistance. As the coordinator for the NFIP in Michigan, MDEQ contracts with FEMA to work with communities to ensure that they understand their duties under the NFIP. Community contacts are done by telephone and by visiting the community. These contacts provide local officials with a "refresher" on the NFIP, in addition to MDEQ permit requirements. These contacts are a very effective means of keeping officials up-to-date. However, due to the number of communities in the NFIP, some communities may be contacted only once every five years or so. Due to the turnover of local officials, more frequent contacts would be extremely beneficial.

Community Participation. Within Michigan there are 1,775 communities, of which 867 (about 49%) were participating in the NFIP as of November 17, 2010. This marks a sizable increase from the 41% that were participating when the previous edition of this plan was written three years ago. There are estimated to be more than 720 communities in Michigan that have flood problems. Because of the existing state laws and the building codes, every community in Michigan meets the minimum standards to participate in the NFIP. The only actions necessary to join the NFIP would be the passing of a resolution indicating an interest in joining the NFIP, adopting an ordinance indicating the State Construction Code is enforced in the community, and completing an application. The MDEQ, in cooperation with the Michigan Attorney General's Office has developed a sample ordinance that may be used by communities when joining the NFIP. A continued effort is needed to make the communities in Michigan aware of the NFIP and floodplain management.

Flood Insurance Purchases. Nationally, it has been estimated that only about 10 to 12% of the eligible properties within the flood hazard areas of participating communities have flood insurance. (It is believed that a similar percentage of participation – approximately 15% – is occurring in Michigan.) There is currently a national advertising campaign to make homeowners aware that flood damages are not covered by their homeowners' policy. In recent years there has been an increased awareness on the part of lenders regarding the flood insurance purchase requirements.

Combining the low participation rate on flood prone properties with the fact that property owners in non-participating communities cannot purchase flood insurance, it can be inferred that Michigan's 24,083 active NFIP policies represent a very small portion of the total number of structures that are considered to be flood prone within Michigan. It is estimated that there are about 200,000 structures in Michigan that are within the 100-year floodplain. This means that only about 12% of Michigan's flood-prone properties are insured against the peril of flooding.

While not a Michigan problem alone, there is still a need to increase the awareness of the public of flooding problems and the availability of flood insurance.

Repetitive Losses. Nationally, it is estimated that about 10% of the properties account for about 40% of all NFIP claims. These properties which continually receive flood damage and are reimbursed for their insured losses are referred to as repetitive loss properties, and are a primary concern for the NFIP. The NFIP Reform Act of 1994 is a first step at addressing repetitive loss properties through mitigation.

The NFIP Reform Act established the Flood Mitigation Assistance Program (FMAP). At full funding, $20 million is made available annually to states and local governments to mitigate future flood losses. The fund is used primarily on repetitive loss structures.

Since 1978, more than $45 million in claims have been paid due to flooding in Michigan. Although that figure is not as high as some areas of the country, Michigan does have its share of repetitive loss properties. (See the Riverine Flooding Section in the Hazard Analysis portion of this plan for more detailed information on repetitive loss properties and flood insurance claims in Michigan.)

Repetitive Loss Reduction Project. Reducing claims of repetitive flood loss properties under the NFIP is a major goal of both FEMA and the State of Michigan. To that end, in 2001 the MSP/EMHSD and the MHMCC (now MCCERCC) embarked on a $3 million statewide repetitive flood loss reduction project using HMGP funding from Federal Disaster 1346-DR-MI. The goal of this project is to acquire / remove or elevate as many as possible of Michigan's repetitive flood loss structures (which totaled 456 at the program start), with particular emphasis being placed on those communities that show a strong willingness and commitment toward repetitive flood loss reduction.

Although it started as a statewide campaign, it quickly became evident that staff and funding limitations necessitated a change in the initial focus of the project. Instead of initiating mitigation work on small numbers of structures in multiple jurisdictions across the entire state, it was determined that it would be more efficient and effective to target individual communities that not only had a high level of risk but also a high level of homeowner and government interest in reducing or eliminating that risk. Early on, a decision was made by the MSP/EMHSD and MHMCC to target structures in "community clusters" to provide opportunities for greater efficiency and economy of scale and activity. After reviewing the repetitive flood loss properties list for Michigan and talking to various state and local officials, it became evident that Monroe County was an excellent place to start with the project. Further analysis revealed that the Village of Estral Beach and Erie Township in Monroe County both had large numbers of structures at risk, and homeowners that were willing and able to undertake mitigation measures to reduce their risk to both riverine and Great Lakes flooding. The Village of Estral Beach was selected as the initial pilot community for this project, and Erie Township was selected at the second pilot community.

In August 2002, the State of Michigan contracted with the engineering / urban planning consulting firm Camp, Dresser & McKee (CDM) to execute and manage this project on behalf of the MSP/EMHSD and the MHMCC. CDM was tasked with contacting all property owners within the Village of Estral Beach and Erie Township that met the repetitive flood loss reduction project criteria, to determine a level of interest in elevating their structure or having their structure acquired. This was accomplished by CDM and the local elected officials by holding a public meeting on November 7, 2002 to describe the scope of the project and the eligibility criteria. Staff from the MSP/EMHSD was also present at the meeting to answer any questions related to programmatic issues. A total of 39 home elevation projects were identified in Estral Beach and 23 were identified in Erie Township. (The situation in Estral Beach is particularly favorable to additional flood mitigation because currently a combination of earthen dike and concrete floodwall, built by the U.S. Army Corps of Engineers many years ago, provides flood protection for the community. However, this flood barrier has been compromised in several locations throughout the years and is only high enough to mitigate the 10-year flood event in some areas of the village.)

After the initial public meetings, interested property owners contacted CDM, which in turn developed an estimate of the cost of the project and conducted a preliminary benefit / cost analysis to ensure the project is cost-effective. The Estral Beach portion of the project involves elevating the 39 flood prone homes a minimum of one-foot above the 100-year flood elevation. Those homes that are subject to wave run up from Lake Erie will be elevated in accordance with recommendations of the MDEQ. Those houses will be elevated between two and 12 feet.

Unfortunately, the contract with CDM expired in late 2004 and could not be renewed within the specified timeframe due to restrictions within the State's procurement process, and its worsening financial situation. As a result, the MSP/EMHSD – out of necessity – took on the responsibility of overseeing and guiding this project through the construction phase to eventual completion, using in-house planning and grant management staff. The MSP/EMHSD assembled a project team and promptly developed an action plan for completing the project. The action plan was developed after conferring with CDM and the Village of Estral Beach on numerous occasions regarding the specifics of what needed to be done to complete the construction phase and then close out the project. Although this transition to in-house management was clearly not part of the original implementation plan for the project, it was nonetheless required based on the situational circumstances in place at the time the CDM contract expired. The MSP/EMHSD has assumed responsibility for project administration and monitoring, grant management, and project closeout.

The MSP/EMHSD staff continues to work with village officials and involved homeowners to complete ongoing home elevations. The project has been extended to August 2011 (from its original August 2010 completion deadline) to accommodate a several-month delay that occurred when the initial federal environmental reviews expired and had to be re-approved, and because of damage that occurred when a tornado struck the village in June 2010 (described in the tornado section of the hazard analysis in this plan). Ironically, one of the homes being elevated was damaged beyond repair by the tornado but the home is being reconstructed and elevated. As of December 2010, a total of 11 structures have been approved for funding for elevation under this grant. All 11 elevation projects have started and two have been completed at the time of this writing.

The elevation / acquisition of the 23 identified flood prone properties in Erie Township will be implemented in a future project as time, resources and circumstances allow. The involved local communities in Erie Township include Grand Beach, La Salle, Luna Pier, Monroe, Rockwood and Detroit Beach.

The Estral Beach project has proven to be a highly successful model for other community-wide home elevation initiatives. It will be replicated in Erie Township and other areas of the state as additional funding for home elevations becomes available.

Natural Rivers Program, Part 305 of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended

Even though the Natural Rivers Program is not intended to reduce flood hazards, it does result in structures being constructed away from the river, and out of the floodplain. The program is very effective when administered as intended. Like any regulatory program, if the administrator and the variance board are aware of the requirements of the program, it is very effective.

Farmland and Open Space Preservation, Parts 361and 362 of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended

The Farmland and Open Space Preservation Program is effective at reducing flood hazards only as long as the property is enrolled. Since the program is voluntary, land can be removed from the program at any time with the payment of a penalty. The program is very effective over a short period of time at preventing development in sensitive areas (such as floodplains); however, from a long-term perspective, the program cannot be considered to be an effective flood hazard mitigation tool unless the property is part of a permanent conservation easement purchased by or donated to the State of Michigan in perpetuity.

Manufactured Housing Commission Act, 1987 PA 96, as amended

The Michigan Manufactured Housing Commission Act and its implementing Administrative Rules provide regulation on the placement of manufactured homes and establishes construction criteria. Manufactured homes are prohibited from being placed within a floodway, as determined by the Department of Environmental Quality. In addition, manufactured homes sited within a floodplain must install an approved anchoring system to prevent the home from being moved from the site by floodwaters, and be elevated above the 100-year elevation. These provisions are highly effective when properly carried out and enforced.

Condominium Act, 1979 PA 59, as amended

Similar to the Manufactured Housing Commission Act (1987 PA 96, as amended) and the Land Division Act (1967 PA 288, as amended), the Condominium Act also requires identification of floodplain limits and places certain restrictions on structures in floodplain areas. Administrative Rule 559.402 states: "The floodplain areas shall be clearly labeled…A common element or a condominium unit, other than a campsite or a marina unit, shall not be constructed where it may be reasonably anticipated that the structures will be damaged by flooding…"

In practice, flood prone condominium projects are identified during the permit application review by the MDEQ. To avoid damage by flooding, the elevation of the lowest floor is stipulated in the state floodplain permit issued under authority of the state Floodplain Regulatory Authority found in Part 31 of 1994 PA 451, as amended. These provisions are highly effective when properly carried out and enforced.

Seller Disclosure Act, 1993 PA 92, as amended

This law requires the seller of any 1-4 family residential property to disclose (on a form prescribed by the Act) known defects including whether the property has flooded or is flood prone. It is hoped that this change in regulation regarding the sale of residential structures will reduce the number of dissatisfied home buyers. The law, however, only applies to existing 1-4 family structures, not vacant land, and it is only as good as the knowledge (and honesty) of the seller.

Michigan Agricultural Programs and Flood Hazard Mitigation

The Michigan Department of Agriculture and Rural Development has several programs designed to reduce the negative impacts of weather related disasters on agriculture and the environment. These programs help maintain adequate drainage, preserve farmland and open space, and develop practices to prevent erosion to reduce the water impacts of flooding. Instituting sound practices on farms – from better design and siting decisions to better

management of manure, fertilizer and pesticides – all help to reduce the negative environmental impacts that accompany flooding and other natural disasters.

Michigan Agriculture Environmental Assurance Program. This program helps prevent agriculture related pollution by ensuring that participating producers are using effective stewardship practices that comply with state and federal environmental laws and standards. The proactive, comprehensive program provides education, on-farm technical assistance, environmental risk assessments, and site / farm specific actions plans. This program does not mitigate flood damage, but does help mitigate the negative environmental impacts associated with flooding.

Conservation Reserve Enhancement Program. This program implements environmentally sound practices on agricultural lands which enhance wildlife habitat, reduce soil erosion on high-risk farmland, increase soil productivity, and improve surface and groundwater quality in and downstream of agricultural areas. Specifically, agricultural land along targeted waterways is taken out of production and improved to prevent erosion and run-off, in exchange for rental payments. This program can be effective in reducing soil erosion and sedimentation in waterways, which in turn helps to reduce the potential for flooding.

Pre-Disaster Mitigation Program

Since its inception in 2002, the Pre-Disaster Mitigation Program (PDMP) has been successfully utilized in Michigan to fund flood mitigation activities. The most prominent example is a flood prone properties acquisition project in Robinson Township (Ottawa County) that was initiated in 2005 using two PDMP project grants:

Flood Acquisition / Removal Project in Ottawa County. Robinson Township is a small rural community in west-central Ottawa County consisting of 5,588 residents. The northern boundary of the Township is defined by the Grand River. From 1994 to 2005, two subdivisions in Robinson Township – Van Lopik Avenue and Limberlost Lane, which collectively have 40 structures and 20 vacant parcels – experienced 12 different flooding events. The majority of these flooding events were caused when ice dams forced the Grand River to back up. The flood stage for the Grand River in Robinson Township is 13.3 feet. The flooding events since 1994 have ranged from 13.3 feet to 18.3 feet, the highest recorded flood being in January 2005. The January 2005 flooding event forced the residents of Van Lopik Avenue and Limberlost Lane to relocate from their homes. Due to the extent of the flooding, the loss of utilities and the damage incurred, some of the residents were not able to inhabit their houses for up to six months, and still others were not allowed to return at all.

Seeing the hardships the flooding caused for the residents of Van Lopik Avenue and Limberlost Lane, officials of Robinson Township, the Ottawa County Emergency Management Office, and the Ottawa County Planning and Grants Office inquired with the MSP/EMHSD about the availability of grants to assist in the elevation or acquisition of these structures. Fortunately for Robinson Township, luck and timing was on their side. In November 2004, a few months before the flooding event, FEMA had announced the open application period for the Pre-Disaster Mitigation Program (PDMP). The PDMP is a nationally competitive grant program intended to provide funding for mitigation measures identified in local hazard mitigation plans. For Robinson Township, securing a competitive grant for this project looked like an uphill battle. First, there was the looming application deadline which was only a few weeks away. The second and perhaps most daunting challenge was the fact that a FEMA-approved local hazard mitigation plan was required in order for the project to be eligible for PDMP funding – and Robinson Township didn't have such a plan.

Understanding the time-sensitive challenges faced by Robinson Township, the MSP/EMHSD offered to provide significant technical assistance to the township and Ottawa County in developing the PDMP project application and a hazard mitigation plan. The first major issue that had to be tackled was how to actually develop the grant application. Because the estimated project cost exceeded the funding cap of the grant, it was decided early on that the project had to be broken up into two separate but related segments – each with its own application. That was the easy part. With assistance provided by MSP/EMHSD, the township was able to successfully develop its two applications within the federal government's "eGrants" online grant management system.

The more difficult issue was how to develop a high-quality hazard mitigation plan that met both the immediate grant application needs as well as the longer-term hazard mitigation needs of the township. One option was to include Robinson Township in the Ottawa County plan. However, that plan was still many months away from being completed. Therefore, it would be necessary to develop a separate plan for Robinson Township in order to meet the looming grant application deadline. (The township would later merge its hazard mitigation plan into the larger Ottawa County coordinated planning activities.)

Developing a high-quality plan in such a short timeframe would require significant technical assistance from the MSP/EMHSD. For the long-term benefit of the Robinson Township residents affected by the flooding, the MSP/EMHSD agreed to put many of its other work priorities temporarily on hold in order to assist the township with its plan development. By working long hours and getting considerable cooperation and assistance from the township (staff and citizens) and Ottawa County, the MSP/EMHSD was successful in developing the Robinson Township hazard mitigation plan within the required timeframe. This was truly a remarkable accomplishment, since it often takes a year or more to complete a plan from start to finish in the best of circumstances. Fortunately, the combination of MSP/EMHSD staff planning knowledge and tenacity, the ready availability of needed data, the existence of an earlier hazard mitigation plan for Ottawa County, an engaged and informed citizenry, and cooperative local officials all came together to make the Robinson Township planning effort a timely success.

In March 2005, the Robinson Township grant applications along with nine other grant applications from other Michigan jurisdictions were submitted to FEMA for funding consideration. In October 2005, the grants were officially awarded to the Township to acquire 60 flood-prone properties.

In all, 18 of the 60 parcels were acquired with the PDMP grants. Separately from the grants, six other parcels were acquired by the Michigan Department of Transportation (MDOT) for a future transportation project. Another six property owners elevated their homes with no financial assistance. In all, 30 of the 60 properties were mitigated in one way or another. Twenty-one homes remain un-elevated in the floodplain and eight of the remaining parcels are vacant. Although not all of the 60 flood prone parcels were acquired, the combination of the planning effort and the good percentage of parcels that were mitigated using grant funding and other means made this project a tremendous success. (Because the parcel acquisitions were strictly voluntary—as is the case in almost all flood prone property acquisitions—it is not uncommon for some property owners to not participate.)

Robinson Township – Then

Robinson Township is at risk from flooding of the Grand River at all times of the year. The January 2005 flood was particularly severe and was the result of ice dams on the river. Damage to homes and personal property was significant, and many homes could not be occupied due to lingering public health and safety threats.

Robinson Township – Now

Some of the flood prone properties that have been acquired, cleared, and restored as open space along the Grand River in Robinson Township using FY 05 PDMP funding.

Shoreline Flooding and Erosion

Much of Michigan's character is defined by the Great Lakes. The beaches provide numerous recreational opportunities, and are also considered prime real estate. Unfortunately, the hazards inherent in coastal areas are not always apparent. In addition, development activities along the shoreline significantly alter the natural ebb and flow of coastal dynamics. The continuing and increasing development of the coastal areas, and the resulting conflicts that arise between users, has resulted in passage of various laws designed to establish regulations to mitigate conflict and environmental degradation.

Great Lakes Shoreland Management Program

Under the Great Lakes Shorelands Administrative Rules, local governments may assume permitting responsibility in erosion, flooding, and environmental areas. In communities designated as flood risk areas, ordinances adopted for participation in the NFIP generally meet the requirements under Part 323 prior to the 1992 amendments and allowed the community to assume permitting authority under Part 323. However, most communities have not taken on the additional enforcement responsibility in high-risk erosion and environmental areas. Therefore, in these communities, a state permit is required for most construction proposed in designated areas. In the high-risk erosion area program, an intergovernmental agreement with the Michigan Department of Energy, Labor and Economic Growth directs building inspectors to withhold building permits in high-risk erosion areas until the state permit is issued. Development proposed in environmental areas is also typically reviewed by the MDEQ in conjunction with wetland regulations.

Local building departments are generally cooperative in enforcing coastal regulations. Efforts are made to keep communication lines open between local enforcing agents to minimize misunderstanding. Thorough knowledge of all regulations prior to start of construction has proven to be the best approach to compliance.

Political Pressures: Anti-Land Use Regulation

Shoreland flooding and erosion mitigation occurs through the MDEQ as mandated by Part 323 of the Natural Resources and Environmental Protection Act. The State relies heavily on local government to inform property owners of the regulations and the need for state permits. Strong communication between state and local officials is a priority to MDEQ staff. The value of lakefront property and the increase in tax revenue is attractive to local governments, resulting in strong political pressure to reduce or eliminate regulation of shorelands. In some instances, zoning ordinances are circumvented through the use of variances, resulting in flood- or erosion-prone structures being constructed.

The current political climate in the Michigan Legislature has a tendency toward a reduction in government regulation of land use. It is not anticipated that additional regulations will be enacted in the near future.

Tornadoes

Tornadoes are nature's most destructive and unpredictable storms, and so it is difficult to economically build structures on a widespread basis, using today's construction methods and materials, that can totally withstand the direct wind forces of a strong tornado. However, effective mitigation includes the reduction of damages and lost lives, not just the complete prevention of harm. Although tornadoes themselves cannot be prevented, it is possible to reduce the loss of life and property damages that result from these hazardous events.

Current data indicate that approximately 85% of reported tornadoes in the United States have wind speeds of 112 miles per hour or less. Most homes or commercial buildings built to conform to the State Construction Code will stand up well to the direct wind forces of these weaker tornadoes. Damage from flying debris may still cause considerable damage to the outside walls and roof of a structure, but code compliance is still an effective start for resisting harm from tornadic winds.

Tornadic winds try to lift off the roof and blow out the walls of buildings. If the structure is built to code, the pressures to lift the roof off are transferred down to the wall frame and foundation, thus reducing the likelihood of failure. In addition, construction techniques of securely fastening roof sheathing to its support frame, tightly fastening rafters to the top of the walls, securely bolting wall base plates to the foundation, and cross bracing gable ends, can all be used to significantly reduce the extent of structural tornado damage. While some damages may still occur, these construction techniques reduce the likelihood of the type of catastrophic damage that results from failure of one or more of the main structural components of the building.

Some damages from flying debris can be prevented or reduced through the use of properly installed protective shutters over windows. (Residents should close such shutters soon after hearing that severe weather warnings are issued because there may not be the time or opportunity to do so as weather conditions worsen.) The use of reinforced masonry construction, although expensive, can also provide additional structural resistance to tornado-related damages. As the building industry continues to make strides in developing wind-resistant siding and roofing materials, and to employ the wind-resistant construction techniques described above, these damages may become less prevalent in the future.

Continued public education, along with early detection, tracking and warning, are also critical to reducing tornado-related deaths and injuries. The promotion of "safe space" concepts within homes, schools, commercial and governmental structures must continue to be stressed by local emergency management officials and other decision makers. The development of tornado "safe rooms" (interior reinforced concrete "closets") should be encouraged in any residential, commercial and governmental structures that do not already offer good protection against tornadoes and severe winds. Residents of mobile home parks are particularly vulnerable and should receive particular encouragement in the development of shelters and safe rooms, and the anchoring of the homes to a secure foundation. Anchoring increases the wind resistance of mobile homes and in this way prevents the extra damages and structural weaknesses that result from wind-induced tipping of the units.

Over the past several decades the number of deaths and injuries caused by tornadoes has dropped significantly in the United States. The widespread use of warning sirens, enhanced radar systems, and weather spotters, coupled with constant public education campaigns by government officials and the media, have dramatically improved public safety during tornado events. However, tornado-related deaths and injuries still occur that are both needless and preventable. Some of the reasons for this include building construction that doesn't meet current codes, people ignoring or not receiving weather warning information, people trying to "outrun" tornadoes in their cars, mobile homes that are not properly anchored, and people failing to secure loose items that turn into flying debris under the forces of severe winds. In addition, tornado "exposure" has increased as previously undeveloped areas are settled, so that what used to be sparsely populated farmland or open space is now more likely to contain homes and businesses that are vulnerable to damages and loss of life. All of these circumstances highlight the need for continued and improved public education, storm tracking and early warning, and the use and enforcement of modern construction techniques and requirements.

Winter Storms

Fortunately, winter storms are one of nature's most predictable weather phenomena. As a result, citizens and communities generally have several hours to several days notice before a severe winter storm hits, thus allowing time to adequately prepare for the event. The physical elements of the event itself generally result in little damage on their own – the exception being death or severe injury caused by prolonged exposure to severe cold temperatures. However, the consequences of the accumulated effects of wind, ice, extreme cold and massive amounts of snow – loss of power and essential services, isolation, collapsed roofs due to snow and ice buildup, blocked roads, downed power lines and debris, traffic accidents, etc. – can cause tremendous (and often deadly) problems for individuals, families, businesses, critical facilities and local governments.

In some ways, snowstorms are the northern states' hurricanes. Generally large in size, they can result in massive debris removal operations (snow, downed trees), loss of power due to downed lines and other damaged electrical infrastructure, loss or reduction in essential services, isolation, and temporary economic disruption. However, damage to buildings is usually minimal if they are properly constructed and maintained. In terms of physical destruction, damage to trees and electrical infrastructure are generally the two primary concerns. Existing measures aimed at mitigating these types of damages are very effective where implemented. However, the problem is that implementation is not widespread and consistent. Few cities in Michigan have active, ongoing urban forestry programs designed to minimize storm related damage to trees. Those that do are often hampered by lack of funding.

Electrical infrastructure mitigation goes hand-in-hand with urban forestry, since most storm related damage to electrical infrastructure is caused by downed trees and limbs. Major electrical service providers in Michigan have ongoing system reliability improvement programs (which include forestry activities), and most new electrical infrastructure is placed underground. However, the vast majority of the existing infrastructure is above ground and

therefore highly vulnerable to storm related damage. Over time, lines and equipment are upgraded with newer, stronger materials. However, severe storms still cause considerable damage to the electrical infrastructure every year. This results in power outages (often prolonged and widespread) that severely tax the capabilities of the utility companies to respond, and citizens and communities to cope with the consequences of the situation.

In terms of winter storm response, sheltering people from the elements, clearing roadways, and maintaining critical public safety services (i.e., police, fire, EMS) are the primary concerns of local officials. Michigan communities are generally well prepared to meet these challenges on their own, sometimes supplemented by mutual aid and state assistance. Fortunately, few people die or are severely injured as a direct result of winter storms in Michigan. In those cases where it does occur, it is usually the result of auto accidents, prolonged exposure to cold temperatures, or overexertion (i.e., heart attack) from snow shoveling. Keeping people inside and off the roads during winter storms would greatly minimize the numbers of deaths and injuries. Continued public information programs in that regard should help. In addition, most communities have active programs to check on the condition of elderly and homebound individuals, both of which are extremely vulnerable during severe winter storms.

Wildfires

The Michigan Department of Natural Resources / Forest Management Division (MDNR/FMD) is committed to a multi-jurisdictional, coordinated wildfire mitigation effort. The MDNR/FMD is actively working to reduce the State's vulnerability to wildfires by:

- Participating in multi-state and interagency mitigation efforts.
- Aiding local communities in developing zoning and subdivision control ordinances that adequately address wildfire mitigation.
- Regulating the time and amount of permits that are given for prescribed burns.
- Conducting research on wildfire prevention, containment and suppression activities.
- Developing fire hazard assessments to aid community and property owners in determining their risk and vulnerability to wildfires.

Lack of Local Government Wildfire Mitigation Initiatives

Despite the ongoing initiatives of the MDNR/FMFMD, wildfire prevention and mitigation must be stressed at the local level if a meaningful reduction in risk and vulnerability is to occur. With fewer than 100 state fire prevention officers and funding often in jeopardy, fire prevention efforts need to be redirected more toward local community initiatives. There is ample room for improvement in mitigating forest fire risk and vulnerability at the local level. One main issue is the lack of emphasis on forest fire risk and vulnerability reduction in local zoning ordinances and comprehensive plans.

Most local zoning ordinances lack provisions for wildfire risk and vulnerability reduction. In addition, comprehensive plans are often not prepared far enough in advance in rural areas to adequately direct development and institute mitigation measures in high-risk fire hazard areas. Communities are not adequately utilizing land use systems that recognize special fire problems and requirements related to vegetation, topography, weather, transportation and access, water supply, and density of development.

Local fire agencies only sporadically review proposed lot splits, subdivisions, severances and other developments for fire protection needs. In general, communities are not requiring large developments to calculate the future fire vulnerability of the development. These calculations are also not required for most variances and special use permits. Builders seeking building permits for additions to homes do not have to retrofit the existing structure to meet wildfire safety and mitigation measures. These measures would include such things as replacing an existing roof covering with a fire-resistant or non-combustible covering, installing smoke detectors and other fire safety controls, or maintaining a "firewise" landscape by providing adequate vehicular access, signing streets, roads and buildings, and providing adequate emergency water supplies.

Regulation of Outdoor Burning

The Michigan Solid Waste Management Act (1990 PA 264), which prohibits the burning of leaves and grass clippings in municipalities over 7,500 in population (unless a local ordinance allows such burning), has resulted in some

reduction in accidental fires caused by the burning of vegetation and yard wastes. This is a significant step. However, there are clearly more steps that can be taken to reduce the number of wildfires, as well as minimize the spread of those that do occur.

Severe Winds (Non-Tornadic)

Severe winds occur with regularity in Michigan, and they often cause considerable damage to buildings, trees, and the electrical infrastructure. Existing measures designed to minimize or eliminate the effects of severe winds, such as enforcement of building codes, strengthening electrical transmission lines and equipment, and urban forestry programs, are effective where implemented in a concerted and consistent manner. As mentioned in the Tornadoes Section, the problem isn't in the mitigation techniques themselves. Rather, the problem is in getting the techniques implemented.

Street trees not properly pruned and maintained will incur damage in severe winds. Electrical transmission lines and equipment that is old, inadequate, or vulnerable to damage from trees and tree limbs is much more likely to fail in a storm. Above-ground electrical lines are more vulnerable to wind damage than are below-ground lines. (Unfortunately, the vast majority of the electrical infrastructure is above ground.) Building roofs that are properly and securely anchored to the wall structure are not as likely to be damaged by the uplifting force of winds. The examples are numerous.

Implementation is the key to all of these measures. Over time, these techniques have proven to be sound and cost-effective. However, unless the measures are implemented on a widespread and consistent basis, their effectiveness is greatly reduced.

Hail and Lightning (Thunderstorm Hazards)

As indicated in the Michigan Hazard Analysis (MSP/EMHSD Publication 103), lightning prevention or protection, in an absolute sense, is impossible. However, the consequences of lightning strikes can be diminished (in terms of deaths / injuries and property damage) through the implementation of such measures as:

- Enhanced early warning of lightning conditions by the National Weather Service;
- Enhanced public education of thunderstorm and lightning hazards through Severe Weather Awareness Week and other appropriate avenues;
- Lightning protection for all critical structures using the systematic lightning hazard mitigation approach advocated by the National Lightning Safety Institute (NLSI);
- Widespread use of local lightning detection systems at such locations as golf courses, pools, sports fields and stadiums, and other outdoor venues; and
- Enhanced emergency planning for all large outdoor gatherings (e.g., sporting events, concerts, campgrounds, fairs, festivals, etc.) that includes provisions for early detection, monitoring, and warning of approaching thunderstorms that could produce lightning.

Local emergency managers are central to all of these efforts and are the key players in the implementation of a community-wide lightning protection program. The MSP/EMHSD actively encourages local communities to address lightning risks as part of their overall emergency planning and hazard mitigation initiatives. Although lightning deaths, injuries and property damage can never be totally prevented, these negative impacts can at least be reduced through a combination of public education, human vigilance, technology, proper building safety provisions, and simple common sense.

These measures have been successfully implemented, in whole or in part, in many Michigan communities. Despite these efforts, Michigan still ranks near the top in the United States in terms of lightning deaths and injuries. Undoubtedly, Michigan's status as an outdoor recreation state contributes heavily to its high numbers of lightning deaths and injuries. The MSP/EMHSD will continue to promote lightning safety and mitigation measures in its ongoing coordination activities with local emergency management programs.

Earthquake

Because Michigan is not located in an area subject to major earthquake activity, local emergency management programs and the MSP/EMHSD generally do not devote much time or effort to this hazard. Even if a major earthquake were to occur in the New Madrid Seismic Zone, the impacts to structures in Michigan would be minimal at

best and mostly cosmetic in nature in well designed and constructed buildings. The greatest impact on the state would probably come from damage (that occurs outside of Michigan) to natural gas and petroleum pipelines that originate in the Gulf of Mexico region of the United States and enter Michigan along its southern border. Such infrastructure failures could cause temporary, but severe fuel shortages – especially during the winter heating months. During the hot summer months, a temporary cutoff of natural gas and petroleum supplies could cause a widespread reduction in the availability of air conditioning, which could adversely impact at-risk groups such as young children, the elderly, and persons in poor health.

Emergency Planning and Earthquake Monitoring

The best measure to address these potential contingencies is good emergency planning that includes provisions for the establishment and maintenance of heating and cooling centers and temporary shelters for the most seriously affected individuals. In general, most local communities in Michigan have adequate provisions in place in their emergency plans to address the conditions that would likely occur in the state in the event of a major earthquake in the New Madrid Seismic Zone. The MSP/EMHSD actively promotes these sheltering concepts in its planning guidance, training and exercising programs, and ongoing coordination activities with local emergency management programs – especially those in southern Lower Michigan.

The Michigan Department of Environmental Quality / Office of Geological Survey (MDEQ/OGS), as the State's primary investigator of geological phenomenon, regularly monitors activities related to a potential earthquake in the New Madrid Seismic Zone. Any findings which could affect earthquake emergency planning are forwarded to the MSP/EMHSD for appropriate action.

Extreme Temperatures

Extreme temperatures are common in Michigan due to its Upper Midwest geographic location and proximity to the Great Lakes. Periods of extreme heat and extreme cold occur virtually every year and each phenomenon creates its own set of dangerous conditions that tend to most seriously impact the most vulnerable segments of the population – young children, the elderly, and persons in poor health. Nothing can be done to eliminate or reduce extreme temperatures; however, there are measures that can be taken to reduce the impacts of these conditions on Michigan's citizens and communities. Such measures include:

- Identification of at-risk persons, with emphasis on homebound individuals that have limited mobility and contact with the "outside world";
- Establishment of temperature / humidity trigger points that activate emergency provisions for the most at-risk groups in the community, including visits to homebound individuals;
- Good emergency planning that includes provisions for the establishment and maintenance of heating and cooling centers and temporary shelters for the most seriously affected individuals (these plans are particularly critical in urban areas and urban centers, as these areas are more likely to have larger numbers of at-risk individuals); and
- Community planning and engineering standards that require that appropriate mitigative measures be taken to prevent deep ground freeze damage to public infrastructure such as water distribution lines and sewer lines.

In general, most local communities in Michigan have adequate provisions in place in their emergency plans to address the impacts to individuals caused by extreme temperatures. The MSP/EMHSD actively promotes these sheltering concepts in its planning guidance, training and exercising programs, and ongoing coordination activities with local emergency management programs – particularly those that deal with large urban centers.

Public Infrastructure Impacts

In addition, the Michigan Department of Environmental Quality (MDEQ) regulates the design, construction and maintenance of community water distribution and wastewater collection / treatment systems in the state. The MDEQ, through its oversight and permitting processes, helps ensure that the newer elements of public water distribution and wastewater systems are able to function adequately during most periods of extreme cold temperatures. However, as was evidenced in the 1994 deep freeze disaster in Northern Michigan (1028-DR-MI), older infrastructure may not hold up as well during prolonged periods of deep ground freeze. As a result, temporary infrastructure failures due to

extreme cold temperatures still occur with regularity throughout Michigan. As these older segments of the infrastructure are replaced over time, this problem is likely to decrease.

Land Subsidence

The primary historical cause of subsidence in Michigan is underground mining, although a substantial number of events have been occurring in urban areas, as a result of water main failures or construction mishaps. Although many areas of the state are potentially vulnerable to mine subsidence hazards, it is safe to say that it is generally not considered a top hazard in most communities (the exception being some sections of the Upper Peninsula). Part of that may be due to lack of specific data on the exact whereabouts of abandoned mines, and part may be due to the fact that subsidence generally has a limited impact area (typically a single site). However, the amount of recent damages in urban areas, as described above, now seems to significantly outweigh damages caused by collapsing mines (and to cause more injuries, as well). Increased funding for urban infrastructure and maintenance would be one way to address this increasing problem.

Mine Subsidence Efforts

The Michigan Department of Environmental Quality / Office of Geological Survey (MDEQ/OGS) monitors and regulates mining activity in Michigan. Working with local officials and the U. S. Department of the Interior, the MDEQ/OGS mitigates mine subsidence problems through special projects aimed at properly sealing mine shafts and otherwise ensuring the structural integrity of underground coal mined areas. Unfortunately, there is very limited state funding for mine subsidence mitigation. Therefore, most of the funding for such projects comes from the federal government. The primary federal funding source is the Abandoned Mine Lands (AML) Reclamation Fund in the Surface Mining Control and Reclamation Act (SMCRA), P.L. 95-87, administered by the U.S. Department of Interior's Office of Surface Mining Reclamation and Enforcement (OSMRE). AML funds are derived through a tax on coal production targeted at reclaiming land and water resources adversely affected by pre-1977 coal mining. These funds can also be used for mine subsidence mitigation measures and salt sealing, which Michigan has done on numerous occasions.

Since 1981, the MDEQ/OGS has directed the expenditure of over $1 million in AML funds on corrective measures at 12 different abandoned coal mines. In addition, more than $800,000 has been expended on mine inventories and other special studies. Unfortunately, there is not enough funding to accomplish all of the mitigation and reclamation work that needs to be done. As recipient and administrator of Michigan's share of AML Fund monies, the MDEQ/OGS is responsible for prioritizing and selecting mitigation and reclamation projects for funding requests. Normally, priority is given to those emergency projects that involve mine lands that present an immediate danger to the public health, safety or general welfare. Typically, such emergencies include landslides near homes and across roads, subsidence occurring under houses and public buildings, mine and coal waste fires, and open mineshafts discovered near populated areas.

Despite those efforts, incidents of mine subsidence still occur with some regularity in areas with abandoned mines. Fortunately, the impact area tends to be small and steps can usually be taken to prevent further collapse and major damage to structures.

Infrastructure-Caused Subsidence

Subsidence caused by leaking underground water and sewer lines is increasingly common in developed urban and suburban areas. This type of subsidence is difficult to detect and usually becomes known only when the collapse occurs. In most cases, whole sections of street and portions of adjacent private property are affected. Once the location of the leak is pinpointed, corrective measures can be put in place to prevent further subsidence incidents from occurring. These situations are typically handled by local public works agencies with engineering oversight provided by the MDEQ/OGS. There are no specific state programs designed to target this type of subsidence problem.

State Hazard Mitigation Goals and Objectives

The State of Michigan's four hazard mitigation goals are:

GOAL 1: Promote Life Safety
Minimize disaster-related injuries and loss of life through public education, hazard analysis, and early warning.

GOAL 2: Reduce Property Damage
Incorporate hazard mitigation considerations into land use planning/management, land development processes, and disaster-resistant structures.

GOAL 3: Build Alliances
Forge partnerships with other public safety agencies and organizations to enhance and improve the safety and well-being of all Michigan communities.

GOAL 4: Provide Leadership
Provide leadership, direction, coordination, guidance, and advocacy for hazard mitigation in Michigan.

Under each goal is a set of hazard mitigation objectives. A full list of these objectives appears, with explanatory descriptions, in a list on the following pages of this plan.

The hazard mitigation goals and objectives listed in this plan were developed by the MHMCC and MCCERCC and the MSP/EMHSD staff after extensive hazards research, consultations with stakeholders, and years of experience in dealing with a wide variety of disasters and emergencies. The goals and objectives, which are necessarily statewide or regional in nature, were developed based on a number of practical and philosophical factors which include but are not limited to the following:

- The desire to minimize hazard-related deaths and injuries to the extent possible.
- The desire to minimize hazard-related property and environmental damage to the extent possible.
- The desire to minimize the number of disasters that occur in Michigan, and their associated response and recovery costs, to the extent possible.
- The desire to minimize hazard-related negative social and economic impacts to the extent possible.
- The desire to enhance and maximize coordination between local, state and federal agencies and applicable nongovernmental organizations in identifying mitigation problems, opportunities and solutions, and in coordinating resources to implement the identified solutions.
- The desire to make hazard mitigation a part of the daily business practices of all Michigan governmental agencies and nongovernmental organizations, to the extent possible.
- The desire to keep hazard mitigation "on the front burner" of current issues, concerns and priorities by institutionalizing it in the comprehensive planning and land development processes at the local and state levels.
- The desire to make hazard mitigation an important part of the daily lives of all Michigan citizens by increasing their awareness of their hazard risk / vulnerability, their willingness to undertake appropriate individual home / business mitigation measures, and their support of community-and statewide hazard mitigation activities.

Development of Statewide Goals
With these and other relevant factors in mind, the MHMCC and the MSP/EMHSD set about in late 1998 and 1999 to develop a core set of hazard mitigation goals and objectives that reflect these practical and philosophical values. Numerous work sessions were held during that period to develop and ultimately refine the plan goals and objectives. This work was carried out primarily through the MHMCC operating committee structure. Advice and assistance from numerous supporting agencies and organizations was solicited during the development of the goals and objectives – primarily through direct contact with the individual MHMCC members. The MHMCC members used this input to assist them in formulating the plan goals and objectives.

Preparer's Note: The goals and the majority of the objectives contained in this plan were developed BEFORE the passage of the federal Disaster Mitigation Act of 2000 and the development of the more detailed risk assessments for critical state owned and operated facilities that are a central part of this plan. The DMA 2000 places significant emphasis on the development of goals and objectives that directly correlate to the risk assessment. That has been enhance in the 2014 plan update by including additional objectives (under goal 2) to address non-flood hazards. However, since many specific hazard mitigation actions must be implemented at a local level, this state plan emphasizes higher-level coordination and funding administration issues that cannot be covered in local plans. Several of the objectives in this plan, for example, are oriented toward integrating hazard mitigation more fully into local comprehensive planning—future-oriented activities which do not relate directly to the results of the risk assessment. Similarly, to increase public knowledge of and support for mitigation measures is not intrinsically hazard-specific, although the results of the risk assessment provide an extensive source of information to distribute through numerous networks, venues, and forms of media, to build public awareness of all types of hazards. These are just two examples of the many plan objectives that are indirectly shaped by the results of the risk assessment, even if not intrinsically hazard-specific. More information appears in the detail of the objectives' descriptions.

After much research, analysis and deliberation, the MHMCC and MSP/EMHSD developed a set of goals and objectives that attempt not only to reduce future hazard-related damage and negative impacts (preventive mitigation), but also to correct existing problems related to land use planning, engineering and construction, land development, and land management (corrective mitigation) that may contribute to an increase in the number or severity of hazards and their resultant damage and impacts. On August 25, 1999, the MHMCC formally adopted the following statewide hazard mitigation goals:

MICHIGAN'S STATEWIDE HAZARD MITIGATION GOALS

1. **Promote Life Safety:** Minimize disaster-related injuries and loss of life through public education, hazard analysis, and early warning.
2. **Reduce Property Damage:** Incorporate hazard mitigation considerations into land use planning / management, land development processes, and disaster resistant structures.
3. **Build Alliances:** Forge partnerships with other public safety agencies and organizations to enhance and improve the safety and well being of all Michigan communities.
4. **Provide Leadership:** Provide leadership, direction, coordination, guidance, and advocacy for hazard mitigation in Michigan.

Development of Objectives

In order to reach these four statewide goals, a number of specific objectives have been identified related to each goal. Those objectives, and an accompanying action plan for each, can be found in the "Mitigation Opportunities, Recommendations, and Implementation" section. (Note: It should be recognized that this list of objectives is fluid and dynamic – constantly changing and evolving as necessary to meet the current problems, concerns, and issues facing the State of Michigan, local governments, and private industry.)

Review of Goals and Objectives for 2014 Plan Revision

For the 2014 MHMP revision, the goals and objectives were thoroughly reviewed by the MCCERCC, MSP/EMHSD, Silver Jackets, and relevant stakeholders (i.e., state and federal agency subject matter experts and nongovernmental organizations). As a result of that process, the four goals were left unchanged but numerous changes were made to the objectives. Many objectives were reprioritized, amended as required, and "retired" (removed) if adequately addressed or determined to be non-feasible given current and projected political and/or fiscal realities. These determinations were based on current and anticipated conditions in Michigan with regard to hazard risks and vulnerabilities, state and local governmental budgeting, and the priorities of the new gubernatorial administration regarding governmental structure and functions. In addition, several objectives related to non-flood hazards were added to the active list in order to expand activities in those areas. In accordance with the requirements of the Emergency Management Accreditation Program (EMAP) accreditation process (in which the State of Michigan is participating at the time of this planning process), objectives address technological and human-related hazards (including homeland security), in addition to those natural hazard objectives required by FEMA as part of the federal DMA 2000 plan approval process.

Selection and Prioritization of 2014 MHMP Objectives

The objectives presented in this updated 2014 edition of the Michigan Hazard Mitigation Plan were selected and prioritized according to the following criteria:

- For objectives that were listed in the 2011 edition of the MHMP, was each objective able to be partially or fully completed? An assessment was made as to whether sufficient progress had been made to enable the objective to be removed from, or assigned a lower priority in, the updated list for 2014.

- Are resources currently available, or likely to be available soon, to allow the objective to be accomplished as written? Objectives that require more resources than are likely to be available were revised, de-prioritized, or removed from the updated 2014 list.
- Is the objective still relevant in the current and projected environment? If some objectives appeared to have become mismatched with (or more relevant for) the current and anticipated trajectory of programs, administrative organization, funding, political support, or other aspects of the current operating environment, they were assigned a new priority, re-worded, added to, or dropped from the updated 2014 list.
- Is the objective appropriate for the agencies available to implement it? Objectives that seemed better-matched for agencies other than those in Michigan's state government (and its MCCERCC partners) were reconsidered for inclusion, or had their priority changed, in light of the currently operating agencies, and their associated responsibilities and programs.
- Have activities been implemented that were not reflected in the 2011 list? Some new objectives have been added to the 2014 plan in order to better reflect activities that are actually taking place in Michigan.

The following subsections add additional detail to these selection and prioritization considerations, including implementation and funding capability, cost-effectiveness, and other aspects of feasibility. Additional information can also be found in the notes that accompany the full list of objectives, in the next section of this plan.

Implementation of Objectives

The MSP/EMHSD and the MCCERCC Hazard Mitigation Committee are jointly responsible for initiating and monitoring the implementation of the mitigation objectives listed in this plan. Council members and MSP/EMHSD staff involved with each objective report (when appropriate) on implementation status at MCCERCC Hazard Mitigation Committee meetings and/or regular MCCERCC meetings. Specific implementation actions taken are highlighted in the "Comments" portion of the "Mitigation Opportunities, Recommendations, and Implementation" section of this plan on a continuous basis as part of the overall revision process. In addition, some implementation actions may be highlighted and discussed in the MCCERCC's "Michigan Community Emergency Response and Citizen Corps Coordination Plan" and/or MSP/EMHSD Publication 106a – "Hazard Mitigation Best Practices: Michigan Success Stories," both of which are widely distributed to state agencies, the Governor's office and Michigan Legislature, and posted for public viewing and downloading on the MSP/EMHSD web site. When significant accomplishments are made on a specific project or it has been completed, the MSP/EMHSD and MCCERCC may (at the discretion of the MCCERCC Chair) issue a media release that highlights those accomplishments and the overall benefits derived from the project (a mitigation "success story").

Hazard Mitigation Opportunities, Recommendations, and Implementation

Overview and General Guiding Principles

The mitigation opportunities and recommendations listed (in the form of objectives) in the goals tables that follow are just that – opportunities and recommendations. Listing an objective does not necessarily mean that it definitely will be implemented. It merely means that the objective could, and probably should**,** be implemented because the basic principles behind the activity (or activities) associated with the objective are sound and will result in a reduction or elimination of damage, impact and suffering caused by natural, technological or human-related hazards. It is hoped that this plan will eventually help make mitigation an ongoing reality in Michigan's local communities, state agencies, and the private sector. The opportunities and recommendations contained in the goals tables that follow are designed to make a real difference in the lives of Michigan's citizens by reducing or eliminating the dangers and costs associated with disasters.

Political, social and fiscal realities must be understood and taken into consideration when implementing hazard mitigation activities. Even the best ideas and opportunities, if not crafted within the parameters of existing system constraints, are more often than not doomed to failure from the start. Some of the recommendations listed in the following tables may be categorized as "pie-in-the-sky," meaning that the idea or activity – even those that are highly meritorious – is not likely to be implemented in the foreseeable future because it may have one or more significant constraints working against it. Nonetheless, those recommendations have been included in the plan because the principles behind the recommendation are strong and they at least warrant future consideration.

In developing mitigation recommendations and implementation strategies for the hazards addressed in this plan, the following general guiding principles have been followed to the extent possible:

- Non-structural measures have been emphasized over structural measures.
- Voluntary measures have been emphasized over mandatory measures.
- Education-based compliance and cooperation has been emphasized over legislated mandates.
- The least expensive alternative has, in general, been emphasized over more expensive alternatives.

Furthermore, the following additional principles will govern the development and implementation of flood hazard mitigation recommendations:

- NFIP-participating communities will have priority over non-participating communities.
- Communities / sites suffering repetitive losses will have greater emphasis.
- Flood mitigation projects will, to the extent possible, be implemented in the following order of priority:
    1. Acquisition and relocation or elevation of flood prone structures.
    2. Drainage projects (culverts, channels, retention / detention ponds, etc.).
    3. Wet and dry flood proofing of structures.
    4. Structural measures (floodwalls, dikes, jetties, etc.).

Funding Sources for Implementation of Mitigation Projects

For each mitigation opportunity or recommendation listed in the following tables, potential funding sources have been identified. For the most part, those sources include the federal Emergency Management Performance Grant (EMPG), and state, local and private funding, and the Hazard Mitigation Assistance program—an umbrella grant program that includes the Hazard Mitigation Grant Program (HMGP), the Flood Mitigation Assistance Program (FMAP), the Pre-Disaster Mitigation Program (PDMP). The Repetitive Flood Claims Program (RFCP) and the Severe Repetitive Loss Program (SRLP) are now considered to be a part of FMAP. A few items still refer to the Homeland Security Grant Program (HSGP), where still considered relevant. Those are the primary funding mechanisms currently used to implement desired mitigation projects in Michigan (and most other states). It should be noted that Michigan does not have a state mitigation fund, although establishment of such a fund used to be a recommended measure under Goal 4 of the Mitigation Opportunities, Recommendations and Implementation Section that follows. (Instead, this has shifted into a new effort to allow MCCERCC to make use of private sector donations—see Objective 4.5 and the description in the next paragraph, below.) It should be further noted that Michigan has had a state disaster contingency fund on the books since 1976, but it has never been funded to its legally established base amount. Philosophically, the Michigan Legislature and Michigan's Governors over the years have been opposed to allocating funds to contingency accounts. Instead, the Michigan Legislature has preferred to allocate state disaster relief funds on an as-needed, case-by-case basis. That basic philosophy continues today and is unlikely to change in the foreseeable future. Any state funding identified in the tables would come from one-time appropriations by the Michigan Legislature or from existing budgets of involved state agencies.

Sources of pre-disaster funding include the federal grants available under PDMP and FMAP. There is still a need for Michigan to compile specific information from local plans in order to better solicit specific hazard mitigation projects within the sometimes-tight timeframes under which applications must be submitted. The main source of post-disaster hazard mitigation funding is the HMGP. However, in Michigan's most recent disaster (#4121, April-May 2013), it has found that the amount of money actually available for hazard mitigation is substantially less than had originally been foreseen, partly due to differences between Preliminary Damage Assessment information and the final figures allocated to the state. There have been numerous cases over the past decade in which Michigan has attempted to gain federal disaster declarations, but in which these attempts have resulted in disappointment. Surrounding states in the region now seem to have gained access to much more funding in recent years, resulting from their successful declaration requests. Some of the successful Michigan requests have been relatively modest in the amount of funds made available, and in some cases, the limited amount of post-disaster funds has meant that they only served a limited portion of the state, rather than a representative selection of communities, statewide. (The fairest distribution in such cases has often been to favor the area specifically covered by the disaster declaration.)

A desirable future work activity for the MCCERCC Hazard Mitigation Committee could involve the identification of specific protocols for creating public/private partnerships and accessing private-sector funding for hazard mitigation purposes. It is unlikely that large amounts of private sector funding will be identified for general hazard mitigation use, but such funding would likely be targeted to specific projects, even if they may turn out to be one-time-only projects and circumstances. Nonetheless, private sector funding can, in many instances, be obtained and is a valuable supplemental funding source for project implementation in the right circumstances. The MCCERCC Hazard Mitigation Committee intends to develop protocols for approaching private sector entities for funding support as a desirable program activity for the future.

It is often possible to successfully fund hazard mitigation projects using other sources of federal funding targeted primarily for other purposes. This typically involves "multi-objective" projects that include, either purposely or coincidentally, hazard mitigation elements. For example, a riverfront parkland acquisition project also includes the added benefit of preventing unwanted development in the floodplain, thereby effectively mitigating potential flooding problems. These types of projects are possible and desirable, but they often are more difficult to implement because more individuals and agencies are involved and the benefit of mitigating hazards is generally not the primary objective. However, under the right circumstances, they can work to the benefit of all involved parties.

Recognizing that fact, this plan includes guidance within Attachment C of this plan, which can provide a "roadmap" to the many governmental and private sector funding programs and mechanisms currently in place that can be used to assist in implementing hazard mitigation projects and initiatives of a multi-objective nature. It points the way to more detailed information sources available to anyone via the Internet, such as the Catalog of Federal Domestic Assistance (CFDA), federal and state agency web sites that describe funding programs, and private philanthropic organization web sites. This information can be used either to help implement projects at the local level, or to identify potential funding sources for mitigation projects of regional or statewide application.

Project Funding Criteria

Pursuant to Executive Order 2007-18, the MCCERCC is responsible for reviewing, prioritizing and selecting all projects for funding under the HMGP, FMAP and PDMP. This responsibility has been extended to also include the RFCP and SRLP (as well as any other new federal grant programs that are established). The MSP/EMHSD and MCCERCC have established specific review criteria and a multi-step review process for carrying out that responsibility.

The review process in each case begins with the MCCERCC Hazard Mitigation Committee, which is responsible along with the MSP/EMHSD staff for screening of solicited applications and potential applicants. For each of the grant programs, the MCCERCC Hazard Mitigation Committee reviews the applications received (project and planning) to ensure applicant, work and cost eligibility and to categorize the project type. The MCCERCC Hazard Mitigation Committee then convenes a State Selection Panel that consists of committee members, selected MSP/EMHSD staff, and state agency representatives with expertise in the particular type of disaster that occurred. The size of the State Selection Panel is left to the discretion of the Hazard Mitigation Committee chair, but typically consists of 7-10 individuals. The State Selection Panel reviews and evaluates each eligible application received (project and planning) and then prioritizes the applications using a 1-5 point numerical scoring system based on the following criteria:

- The project demonstrates sound hazard mitigation techniques.
- The project is listed in the applicable local hazard mitigation plan.
- The project supports the Michigan Hazard Mitigation Plan.
- The project meets the required eligibility criteria.
- The project is suitable for funding under the HMGP / FMAP / PDMP / RFCP / SRLP rather than other funding programs.
- The project is consistent with the MCCERCC approved strategy for the federally-declared disaster (if applicable).
- The project completely or substantially solves the problem.
- The project provides a permanent or long-term solution.
- The project is likely to be cost-effective based on physical damages prevented.
- The project will not create negative environmental effects.

- The project is consistent with other projects, initiatives, and state agency priorities.
- Communities with the highest risk.
- Communities with the greatest number of repetitive loss properties.
- Communities with the greatest number of NFIP insured structures.
- Communities with the most intense development pressures.
- Communities with the largest increases in population and/or physical development.
- Communities that have the ability to successfully implement hazard mitigation projects within the required timeframes.
- Communities that have expressed interest in hazard mitigation activities.

The numerical scores for each project are added together and then divided by the number of voting members of the State Selection Panel, thereby establishing an average score for the project. The projects are then ranked according to their numerical score. (See Attachment C for a sample project scoring matrix and a further explanation of the prioritization criteria used.)

Generally, the scored projects are then funded according to their ranking, up to the established federal funding limit, after receiving full Council concurrence. However, in some cases the Council may establish special priority for certain types of projects and those projects would then receive the highest funding consideration for that disaster. For example, the Council may determine that acquisition or elevation of flood prone structures is the highest priority for a federally declared disaster and those types of projects would receive consideration over other types of projects for HMGP funding. Any special funding priorities established would be set forth in the mitigation strategy developed jointly with FEMA for that disaster.

For the nationally-competitive PDMP and RFCP, project applications are reviewed and prioritized for funding consideration by the Council upon recommendation of the MSP/EMHSD mitigation staff. All PDMP and RFCP applications are submitted directly by applicants to FEMA via the federal E-Grants system. A prioritized project application listing is submitted by the MSP/EMHSD to FEMA for federal review by national review committees established by FEMA. Once the project applications enter that review process, there is no guarantee that the State's highest priority applications will actually be selected for funding under the PDMP or RFCP. In some cases, lower priority projects may be selected because the national review committee felt that the higher priority projects were not eligible due to technical problems with the project or a lower benefit / cost ratio. It is also possible that NO projects will be selected for the State of Michigan due to the competitive nature of the programs.

For the SRLP, the eligible properties for the competitive phase of the grant program are pre-identified by FEMA. Michigan currently has eight properties that have been pre-identified as being eligible for funding consideration under the SLRP. In the event that project applications received exceed available funding possibilities, the projects will be prioritized and selected for funding consideration on the basis of the highest benefit-cost ratio as determined by the applicant and the MSP/EMHSD staff. Other prioritization and selection criteria may be instituted by the MCCERCC Hazard Mitigation Committee based on current or anticipated local conditions or other relevant factors.

Assurances:
The State of Michigan will comply with all applicable Federal statutes and regulations during the periods for which it receives grant funding, in compliance with 44 CFR 13.11(c) and will amend its plan whenever necessary to reflect changes in State or Federal laws and statutes as required in 44 CFR 13.11(d).

At the time of application for FEMA mitigation grant funds, applicants sign FEMA Form 20-16 certifying that they will comply with applicable standard assurances as follows: (FEMA Form 20-16A) Assurances for Non-Construction Programs, (FEMA Form 20-16B) Assurances for Construction Programs, (FEMA Form 20-16C) Certifications Regarding Lobbying; Debarment, Suspension, and other Responsibility Matters; and Drug-Free Workplace Requirements, and (FEMA SF-LLL) Disclosure of Lobbying Activities.

At the time of grant award for FEMA mitigation grant funds, recipients sign a grant agreement officially certifying that they will administer the grant in accordance with Federal regulations including (but not limited to) Titles 2, 31, and 44 of the Code of Federal Regulations, OMB Circulars, and applicable State laws and statutes.

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MITIGATION OPPORTUNITIES, RECOMMENDATIONS, AND IMPLEMENTATION

Under the four planning goals, each objective is listed with one or more specific implementation methods, a priority classification, targeted completion date, potential funding source(s) if needed, explanatory text descriptions, current status description, descriptions of benefit-cost considerations (including technical feasibility and environmental soundness), and a reference or description of the item's relevance to a full range of hazards (including technological and human-related hazards).

The current implementation status ("2014 status") of each objective from the 2011 plan edition can be found in the "Comments" section under each objective, including an explanation of any delays or implementation problems.

Objectives from the previous 2011 plan that have been completed or removed (in their entirety) from further consideration (due to non-feasibility, consolidation or other reasons) have been transferred to the tables titled "Compendium of Addressed/Removed Objectives" at the end of this section.

To help keep retain continuity between this updated plan and the previous edition, and to assist in the tracking of implementation progress over time, Mitigation Objectives that have been completed or removed from consideration still appear here, but with strikethroughs to denote elements that are no longer considered current. The referenced Compendium table toward the end of this section then summarizes of all those objectives that have been completed or removed. Benefit-cost review text is provided for every objective, to explain why a net benefit would be expected if sufficient resources, staff time, interagency coordination, political priorities, etc. are sufficiently available to allow the objective's implementation. There are cases in which an objective has been removed due to a lack of these things, even though an explanation is provided about why the activity could result in a net benefit. In these instances, the "2014 status" text provides the most important reason(s) for the objective's current implementation status.

The list of currently active, prioritized objectives for the time period 2015-2024 is summarized in the corresponding table entitled "Summary of Target Completion Dates for Plan Objectives," at the very end of this section.

Goal 1

Promote Life Safety: Minimize disaster-related injuries and loss of life through public education, hazard analysis, and early warning.

Objective 1.1: Increase public / private sector awareness of hazard related dangers and mitigation solutions.
Implementation Method:

- State agencies will distribute information about hazard mitigation through training sessions, the internet, professional networks, and other readily available means.
- ~~Conduct a statewide mitigation marketing and public education campaign targeted at seven key professional groups.~~
- ~~Produce and distribute a CD with discipline specific hazard mitigation information and recommendations / best practices.~~
- ~~Conduct introductory training (on the CD contents) for each target group as needed / appropriate.~~

Committee Priority: HIGH (ongoing)
Completion Target: 2016
Funding: HMA
Comments: An HMGP project under Federal Disaster 1346 (Statewide Mitigation Marketing and Public Education) had allowed the development of a notification "postcard" development (Phase I) with contracted assistance provided by Zimmerfish Associates (a Lansing-based public relations and advertising firm). Phase II had involved the development, by state employees, of mitigation educational materials specific to seven targeted professional groups, for distribution on CD-ROM. 2014 status: Instead of proceeding with the original marketing vision, staff has found it more efficient to develop and update existing guidance documents for the widest available distribution through internet web sites. This transformed objective can therefore be considered an ongoing activity.

BC REVIEW: Many casualties occur only because people were unaware of the actual risks present in hazards such as lightning, severe winds, industrial accidents, floods, hazardous materials incidents, public health emergencies, or wildfires. By building awareness through the provision of instructional materials and partnerships with other agencies (governmental, media, educational) at the local, state, and federal level, casualties are certainly prevented, for costs that are far less than most other projects. For example, the web posting of a booklet involves negligible marginal costs and therefore may pay off it its reading prevents even a single life from being lost. For example, the mere awareness of actual risks from lightning for persons outdoors may save lives.
ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: This item is relevant for all hazards.

Objective 1.2: Encourage and promote multi-hazard emergency plans in all public and private institutions, to include provisions for mitigating applicable hazards.
Implementation Method:
- Provide planning guidance, technical assistance, and continuous follow-up to applicable facilities, as required.

Committee Priority: HIGH (ongoing)
Completion Target: 2016
Funding: State Funding (General Fund), HMA, EMAP, etc.
BC REVIEW: Federal funding has been used for the development and maintenance of these plans, in accordance with the relevant regulations. Plan development is not evaluated for a cost-benefit ratio in the way that physical projects are (although federal funding for physical hazard mitigation projects requires FEMA-approved state and local plans to be in place, and the development of emergency response plans is an ongoing activity associated with the Emergency Management Performance Grant at both the state and local level). In view of the enormous potential impacts of hazards such as transportation accidents, terrorism, wildfires, and infrastructure failures, it clearly makes sense to have coordinated planning efforts taking place throughout the state. Such plans also help to justify budgets and priorities established for grant fund use. The planning process requires the involvement of multiple agencies and thus encourages these other agencies to contribute their efforts and resources toward at least some of the goals, activities, and projects identified by the plans. It has been reported by some local emergency management programs in Michigan that the benefits realized from multi-agency coordination, by themselves, were already considered to justify the local planning efforts, even before the plan had been completed.
Comments: 2014 status: The MCCERCC Hazard Mitigation Committee decided to re-classify this from low to high priority. Michigan schools are now required by 1999 PA 102 to plan for incidents of violence and other hazardous situations. Virtually all state owned facilities have an emergency plan in place that addresses a wide range of hazards. Community and site planning for hazardous materials are ongoing activities and one of the main missions of MCCERCC. These are ongoing activities that will be continued and supported by state staff, within resource limitations. State agencies also provide training to many persons in these subjects.
ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: This item is clearly relevant for all hazards.

Objective 1.3: Promote local early warning systems and capability.
Implementation Method:
- ~~Develop state recommended standards / best practices for early warning systems and capability – to include such factors as population coverage, specialized needs for critical facilities, etc.~~
- ~~With the assistance of local emergency management programs, conduct a comprehensive study of early warning coverage throughout the state to determine needs, gaps and shortfalls.~~
- Use information from local hazard mitigation plans to assess gaps in warning system coverage.
- Assist with funding warning systems and warning sirens in local jurisdictions, through the administration of FEMA Hazard Mitigation Assistance grant funds.

Committee Priority: MEDIUM
Completion Target: 2019
Funding: EMPG, HMA, HSGP
BC REVIEW: The great value of human life and health, and the relatively low cost by which many warning systems can alert large numbers of persons about hazardous events and conditions, warrant continued emphasis as a very cost-effective way of preventing casualties from all types of large-scale hazards. Michigan has been involved in the administration of federal funds that have been directed toward warning systems, with local emergency management programs themselves proposing the specific locations for sirens, and areas needing coverage by new warning systems. The selection process for these proposed warning systems involves an explicit comparison between the costs of each

outdoor siren and the number of persons living in the proposed siren's coverage area. Other types of warning systems, such as the provision of NOAA weather radios to facilities (including equipment that had been specially adapted to serve the hearing-impaired), the installation of radio relay towers, have also been funded. This is done in accordance with FEMA benefit-cost standards, typically through the use of "5%" State discretionary funds under HMA.
Comments: 2014 status: The MCCERCC Hazard Mitigation Committee decided to re-classify this from low to medium priority, reflecting the fact that many sirens have been funded by EMHSD through the use of federal funds available for the purpose. At certain times, the frequency of that activity would have qualified this action for high priority status, but the funds available for this activity have been quite limited in recent years. This objective was scaled back to reflect actual resources projected to be available. The State endorses the nationally-recognized Emergency Management Accreditation Program (EMAP) standards for early warning systems and capability as part of its ongoing local emergency management and hazard mitigation planning efforts. Federal mitigation grant funding will be provided, where available and appropriate, for future early warning capability enhancement projects, but this may only mean a small fraction of the mitigation funds available after a declared disaster.
ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: This item is relevant for multiple hazards.

Objective 1.4: Promote the concept of "safe rooms" within homes, businesses, and local/state governmental facilities to prevent and minimize injury and loss of life in tornadoes and severe winds.
Implementation Method:
- Print and make available FEMA's "safe room" construction plans; also permanently post the plans on the MSP/EMHSD web page.
- Work with the Michigan Committee on Severe Weather Awareness to promote safe rooms as a viable option for severe storms protection.
- As circumstances allow, develop prototype "safe rooms" within public buildings to serve as demonstration projects.
- Develop new (or enhance existing) safe space public information materials for mobile home residents.

Committee Priority: MEDIUM
Completion Target: 2019
Funding: HMA, EMPG
Comments: 2014 status: The MCCERCC Hazard Mitigation Committee decided to re-classify this from high to medium priority. Safe room demonstration project funded at Michigan State University Day Care Center under HMGP for Federal Disaster 1346. (This project, which includes eight safe rooms, was completed during 2002.) Bullet 1 – This documentation is available in hardcopy from MSP/EMHSD, and on a FEMA web site, referenced by the MSP/EMHSD web site. Bullet 2 – This is an ongoing effort. Bullet 3 – A safe room demonstration project was funded at the Grand Traverse Band of Ottawa and Chippewa Indians Reservation in Antrim, Benzie and Charlevoix Counties. Consisting of six safe rooms, it was completed in August, 2008. Bullet 4 – This is an ongoing effort.
BC REVIEW: Certain safe room projects have been shown to be cost-effective life-protective measures even when calculations have been focused exclusively on severe wind events. Safe rooms are potentially useful for other types of hazards for which sheltering may be useful, which might increase the cost-effectiveness of this strategy. (Technological and human-related hazard events that may result in a need for "sheltering in place," such as terrorism, nuclear attack, nuclear power plant accidents, or hazardous materials incidents; or for social distancing in response to public health emergencies or bioterrorism.) Each safe room location proposed for grant funding is considered on a case-by-case basis, using a FEMA-established quantitative assessment. (Additional safe room projects may be privately implemented, without the use of grant funds, by business and residential owners who have independently decided that the projects are useful.)
ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: Yes – winds plus technological/human hazards
The concept of a fallout shelter now dates back many decades, although such shelters have historically seen much more use as tornado and storm shelters. An increased concern with terrorism could again bring new emphasis to all the sheltering functions that safe rooms might serve.

Objective 1.5: Support and utilize a system of real-time rainfall and river flow gauges throughout Michigan as part of an overall flood warning system.
Implementation Method:
- Support for multi-agency system of stream gauges and inter-gauge interpolation for local, state and federal users.

- Incorporate stream gauge system and data into State hazard analysis and resource protection activities.
- Encourage local and regional agencies to consider or make use of stream gauge data in their own activities.
- Maintain weather web site to display precipitation information so that agriculture and fire weather notice and actions may be undertaken in a timely manner.

Committee Priority: MEDIUM
Completion Target: 2019
Funding: Federal Funding (current effort led by U.S. Geological Survey; partnering agencies in Michigan)
Comments: Several state agencies supported a U.S. Geological Survey grant proposal to obtain funds for inter-gauge interpolation of stream gauge data during 2013. The "StreamStats" system would provide this information to local, regional, state, and federal agencies. Stream gauges are in place on many rivers throughout the state, but conditions between the gauges must be interpolated, to make the gauges maximally effective. 2014 status: This objective was substantially changed from the 2011 plan, to reflect recent activities involving government agencies, and although the committee re-classified it from LOW to HIGH priority, a subsequent lowering to MEDIUM was considered more appropriate when an update from USGS revealed that obstacles to the funding process had appeared. The fourth bullet point is addressed by an MDNR web site at http://glffc.utah.edu/.
BC REVIEW: Many gauges are already in place throughout Michigan as part of a real-time monitoring system (see the WaterWatch web site at http://waterwatch.usgs.gov), but the gauge locations do not cover all known floodplain and at-risk areas. Although an expansion of the gauge locations does seem to be cost-effective within floodplain areas that contain development, the capacity to use computers to interpolate stream conditions between these gauges would provide extra information for many areas throughout the state, at a reduced cost. Although designed for flood mitigation, these gauges also proved useful in the 2010 Enbridge pipeline break disaster, in which a large amount of fuel was accidentally released into the Tallmadge Creek and Kalamazoo River. Immediate access to water level measurements provided useful information for emergency responders, technicians, and engineers.
ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: This particular item focuses directly upon natural (hydrological) hazards, although flood-related preparedness and response can also relate to the prevention of damages and impact that result in secondary hazards (from infrastructure failure, transportation accidents, hazardous materials incidents, etc.)

Objective 1.6: Develop comprehensive hazard analyses / risk assessments (as part of a hazard mitigation plan development process) in all local emergency management program jurisdictions to address all pertinent natural, technological and human-related hazards.

Implementation Method:
- Multi-year hazard analysis development process initiated in FY 2000 and is implemented by municipal and county governments and their partnering agencies, making use of local grant agreements (annual work plans for EMPG-funded emergency management programs) and dedicated hazard mitigation planning staff in MSP/EMHSD.
- Create hazard area data sets using the locally compiled and reported hazard data.
- Overlay the hazard area data on the critical facilities inventory and relevant population data to identify and further define and quantify risk and vulnerabilities.

Committee Priority: HIGH/ONGOING
Completion Target: 2016
Funding: EMPG, HMA
Comments: Local emergency management program jurisdictions (and their partnering agencies) use printed guidance materials, plus input and training opportunities, to develop a detailed hazard analysis as part of their local hazard mitigation plan development process. Local hazard data can be compiled by the MSP/EMHSD in detail over time, but in general form has already been taken into account during updates of the Michigan Hazard Analysis and Michigan Hazard Mitigation Plan. Some of this information is used at the state and local levels to develop and select hazard mitigation projects and to make more informed hazard mitigation decisions. 2014 status: This objective is still valid and remains an ongoing activity for MSP/EMHSD. It ties in with other assessment processes overseen by different branches of government, such as the flood map updates performed in coordination with MDNR. Bullets 2 and 3 are medium-term activities that rely upon accumulated information readily usable in Geographic Information Systems.
BC REVIEW: Federal funding has subsidized the development of local hazard analyses and mitigation plans in about 100 local Michigan EM programs. Since plans assist with quality hazard mitigation project selection, and the tens of millions of dollars so far spent on hazard mitigation has been estimated to save about 3 times as much in long-term

reductions in emergency response costs, property damage, environmental impacts, loss of life, and economic/business impacts, it has been deemed worthwhile to include the costs of planning as part of that calculation.
ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: This item addresses all types of hazards.

Goal 2

Reduce Property Damage: Incorporate hazard mitigation considerations into land use planning / management, land development processes, and disaster resistant structures.

Objective 2.1: Increase knowledge of urban/regional planners and emergency managers about sound land use and development practices that can help reduce long-term hazard risks and vulnerabilities.

Implementation Method:

- Partner with accreditation organizations for undergraduate and graduate city, urban, and regional planning programs at Michigan colleges and universities, to encourage integration of hazard mitigation principles and practices into comprehensive planning courses, and/or the development of a course (or courses) that discuss same.
- Partner with the American Institute of Certified Planners (AICP) and the American Planning Association to include questions pertaining to hazard mitigation on the exam for AICP certification.

Committee Priority: HIGH (Ongoing)
Completion Target: 2016
Funding: EMPG
Comments: 2014 status: The priority of this item was changed from Medium to High. A Hazard Mitigation / Comprehensive Plan Interface course is included in MSP/EMHSD PEM training requirements, and the course is consistently offered as part of the MSP/EMHSD training curriculum. In addition, hazard mitigation training sessions and presentations have been offered to planning and urban studies students at Wayne State University, Michigan State University and the University of Michigan at various times since 2001. These sessions and presentations continue to be offered as requested. In recent years, awareness and outreach has been greatest at Michigan State University, due primarily to the convenience of its location and the great overlap between State government and university social networks. Other educational institutions are hereby encouraged to inquire about having a guest speaker from EMHSD on the topics of hazard awareness, hazard vulnerabilities, and hazard mitigation activities. Outreach to additional Michigan universities and colleges will occur in the next couple of years (high priority). More widespread presentations have occurred at conferences around the state.
Information on the FEMA Mitigation Management Series training courses has been included in recent MSP/EMHSD Training Catalogs. Planning guidance is provided online and in MSP/EMHSD Publication 207a—"Hazard Mitigation Planning Handbook," which is scheduled for update in the next year (high priority). This document has been widely distributed to the planning community and to other professional disciplines involved in hazard mitigation and/or land use planning in Michigan.
BC REVIEW: The costs of guidance activities are being minimized through the use of internet resources. Guidance documents can be readily accessed from federal and state agency web sites, and their use is encouraged during correspondence, courses, and presentations. Selected speakers promote this objective through sessions at already-established conferences. Since these conferences are already held periodically, costs are not great to simply add or fill one of the sessions with a speaker on the subject. The publication of articles and letters in planning magazines and newsletters (or editorial postings on web pages and associated web logs) is also considered to be a very cost-effective means of reaching a large number of professionals. The costs of such activities would easily be justified if hazard awareness allows even just a few extra lives to be saved.
ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: This item is relevant for all types of hazards, and the urban and regional planning profession has traditionally sought to foresee and address such issues as infrastructure failures, transportation accidents, and potentially conflicting land uses (e.g. the segregation of industrial hazardous materials handling from schools and residential areas). Michigan's guidance documents and plans seek to expand planners' awareness of additional types of spatial and systemic interactions, such as the potential impact of hazards upon critical facilities, special populations, and other emergency management concerns (such as the capacity for evacuation and other emergency response actions within a vulnerable area).

Objective 2.2: Further define identified flood vulnerabilities in state owned/operated critical facilities.
Implementation Method:

- Conduct detailed follow-up studies of vulnerable state owned/operated critical facilities to help to determine the types of "brick and mortar" projects that would be required to permanently reduce identified facility vulnerabilities to flooding.
- Follow up with the Michigan Department of Technology, Management and Budget (MDTMB) regarding the implementation of study recommendations in affected facilities (as time, circumstances, and resources permit).

Committee Priority: MEDIUM
Completion Target: 2019 (Phased Implementation)
Funding: HMA, FEMA HMTAP, RiskMap, USGS, etc.
Comments: 2014 status: The priority of this objective was raised from Low to Medium. The Michigan Hazard Mitigation Plan itself provides a mechanism for accomplishing this task, although for homeland security purposes, the detailed list of critical facilities is suppressed in the public version of this document (Attachment A). More extensive analysis using Geographic Information Systems is anticipated to follow within the next 5 years or so. A detailed study of vulnerable state owned/operated critical facilities would help to determine the types of "brick and mortar" projects that would be required to permanently reduce any identified facility vulnerabilities to flooding. However, such a study may involve multiple agencies, or extra staff support through a FEMA HMTAP contract. Additional (flood) Map Modernization activities continue to occur in Michigan Counties. The ready availability of digitized floodplain information across Michigan will thus enable the quality of flood analysis to improve with subsequent editions of the MHMP. However, staff time (or HMTAP support) will need to be identified to make full use of available resources in producing a detailed analysis, and further dFIRM progress is still being awaited.
BC REVIEW: Specialized Geographic Information System resources will be the tool that makes this kind of research feasible. As digital flood information becomes available from the remaining Map Modernization projects in Michigan, it can be compared with other digital geo-data. The result can take the form of detailed maps that estimate flood risks throughout the state's diverse facility locations. Updated lists of critical facilities have recently been obtained for this 2014 plan update, and consolidated digital flood maps should be available for comparison over the next several years. A detailed assessment will still involve considerable staff time, but multiple agencies have taken this GIS approach to the subject, and large portions of the work might therefore be accomplished more quickly than a single agency could handle the task. A complete "layer" of floodplain areas throughout the state, "overlaid" with a complete layer of critical facility locations, would provide an ideal starting point, followed by further considerations of local topography and "first floor elevations" for facilities that may be at-risk. As with planning activities, the expected benefits of hazard mitigation activities that are informed by an analysis of risks would be expected to exceed the costs of that research.
ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: This item is specific to the flood hazard, although some of the critical facilities in question involve other types of emergency concerns, such as public health, energy emergencies, transportation accidents, and infrastructure failure. Moreover, some of the topographic and hydrological analyses can be useful for hazards such as pipeline breaks, chemical spills, or water contamination.

Objective 2.3: Identify critical floodplain storage areas within the state and enter the data into appropriate Geographic Information Systems to enhance future land use planning and development decision making.
Implementation Method:

- Conduct a study of critical floodplain storage areas and digitize the results.
- Make the results available to all appropriate land use planning and regulatory agencies in the state.

Committee Priority: LOW
Completion Target: 2024 (Phased Implementation)
Funding: HMA, CAP, FEMA HMTAP, State Funding (General Fund)
Comments: Such a study would follow Objective 2.2 and therefore take extra time to implement. Previous plans had referenced the use of FEMA HMTAP, but such assistance was not used for this objective. Completion of digital flood mapping first needs to occur. 2014 status: This objective is still valid for future implementation. However, implementation is contingent upon further digitization of FIRM information.
BC REVIEW: Further development of digital geographic data sets may be needed on the part of specialized geologic or hydrologic agencies to make the costs (mostly staff time for data preparation and processing) lighter. With further

progress on that task, and confirmation that modeling capabilities are sufficiently valid, greater certainty about the cost-effectiveness of this objective would result.
ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: This item is focused upon flood prevention, but may alleviate secondary flood impacts that involve other types of hazards.

Objective 2.4: Acquire/remove or relocate residential and commercial structures currently occupying floodways of Michigan rivers and streams.
Implementation Method:
- Identify structures in floodways.
- Acquire / relocate at-risk structures.

Committee Priority: HIGH
Completion Target: 2016
Funding: HMA
Comments: 2014 status: Being addressed by ongoing Hazard Mitigation Assistance projects such as those in Ann Arbor and Plainfield Township. Previous work had included acquisition projects in Robinson Township (Ottawa County). The acquisition and relocation of structures occupying floodways (and floodplains) of Michigan rivers and streams remains a top-priority mitigation activity that is consistently identified for funding consideration under the various HMA program funding cycles.
BC REVIEW: The evaluation of this objective is typically assessed on a case-by-case basis, and the assent of private property owners is essential. In the case of grant-funded projects, a specific benefit-cost analysis calculation is required by FEMA to demonstrate the cost effectiveness at each proposed project site. Thus, those specific projects to be funded with federal matching grants will have had their cost-effectiveness verified.
ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: This item focuses on flood hazards.

Objective 2.5: Acquire/remove, relocate, or elevate the worst repetitive-loss structures in Michigan.
Implementation Method:
- Identify repetitive loss structures.
- Acquire / relocate or elevate repetitive loss structures.

Committee Priority: HIGH
Completion Target: 2016
Funding: HMA
Comments:
2014 status: (Refer to the update narrative for Objective 2.4.) The acquisition and relocation of repetitive loss structures in Michigan remains a top priority mitigation activity under this plan. The list of repetitive loss properties in Michigan has been substantially reduced in recent years.
BC REVIEW: The evaluation of this objective is typically assessed on a case-by-case basis, and the assent of private property owners is essential. In the case of grant-funded projects, a specific benefit-cost analysis calculation is required by FEMA to demonstrate the cost effectiveness at each proposed project site. Thus, those specific projects to be funded with federal matching grants will have had their cost-effectiveness verified.
ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: This item focuses on flood hazards, although some repetitive loss properties may involve businesses that handle hazardous materials (or provide valuable community services), and thus help to prevent secondary harm from technological hazards.

Objective 2.6: Encourage Community Wildfire Protection Plans and establish and sustain additional FIREWISE communities, statewide.
Implementation Method:
- The MDNR will assist communities in developing Community Wildfire Protection Plans (CWPP).
- Communities with completed CWPPs are to be encouraged, as appropriate, to obtain FIREWISE designations to address their wildfire risks/vulnerabilities (where local willingness exists to establish and sustain the program).
- As MDNR staff resources allow, work with the identified communities to focus local activities to meet FIREWISE program requirements, fire-related elements of their CWPPs, “fire adapted community” standards, etc.

- Formally recognize outstanding CWPPs, examples of FIREWISE community participation, "fire adapted communities," and other wildfire-related achievements, as a "best practice" for other Michigan communities to emulate.
- Expand wildfire mitigation to include related efforts, such as the "fire adapted communities" standard, referenced in the new guidance document available at http://www.fs.fed.us/openspace/fote/reports/GTR-299.pdf.

Committee Priority: HIGH
Completion Target: 2016
Funding: HMA, EMPG, State Funding (General Fund)
Comments: 2014 status: The MHMCC and MDNR Forest Management Division began a joint effort to establish pilot "FIREWISE" communities in Michigan in 2001, and to expand the "FIREWISE" program statewide. A state "FIREWISE" Conference was held in December 2001. A statewide fire threat assessment project was partially funded under the HMGP for Federal Disaster 1346. This phase was completed and 1346 disaster funds have been closed out. Wildfire mitigation efforts are more diverse than just the FIREWISE program, so adjustments have been made in this objective, to recognize multiple means of increasing wildfire resilience and safety. Part of this objective had involved the completion of the "Wildfire Prevention in Southern Michigan Project" under Federal Disaster 1346-DR-MI, a disaster that had provided hazard mitigation funding which has since been closed out. Future, relevant projects covering multiple areas of the state are being promoted as time, resources and circumstances permit. (This objective had been part of 2.20 in the 2011 edition of the MHMP.)
BC REVIEW: This strategy would encourage CWPP, "Firewise," and other community preparedness and wildfire mitigation activities. Since it need not add heavy administrative or staffing requirements, and would be adopted by communities that have substantial wildfire risks, its guidance and coordination efforts toward wildfire preparedness, mitigation, and management is considered to be clearly cost-beneficial for these communities, in light of the substantial wildfire costs they have endured.
ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: This item addresses the wildfire hazard, which can also help to protect against the failure of critical facilities and infrastructure which may be located in the wildfire risk area.

Objective 2.7: Promote and assist with flood mitigation projects in all vulnerable areas, statewide.
Implementation Method:
- The MDEQ will continue their flood mapping coordination work, dam safety programs, NFIP outreach, and other activities to alleviate general flood risks (beyond the specific floodway and repetitive loss sites identified in Objectives 2.4 and 2.5).
- MSP/EMHSD will continue to provide technical assistance with, and promotion of, hazard mitigation planning that identifies potential at-risk sites for flood mitigation activities.
- MSP/EMHSD will continue to administer grant programs that allow federally subsidized flood mitigation activities to occur.
- Develop ways to evaluate flood damage to and caused by the failure of sewage handling systems.

Committee Priority: HIGH
Completion Target: 2016
Funding: HMA, EMPG, State Funding (General Fund)
Comments: 2014 status: This is a new objective, added to the 2014 plan in order to more broadly address flood mitigation activities beyond the more narrowly defined locations already listed under Objectives 2.4 and 2.5.
BC REVIEW: The evaluation of flood mitigation projects are typically assessed on a case-by-case basis, and the assent of private property owners is essential. In the case of grant-funded projects, a specific benefit-cost analysis calculation is required by FEMA to demonstrate the cost effectiveness at each proposed project site. Thus, those specific projects to be funded with federal matching grants will have had their cost-effectiveness verified. Hazard mitigation planning has long been considered to be cost-beneficial in order to identify and prioritize viable flood mitigation projects, and therefore is a federal requirement for the allocation of grant funds to specific projects. The final bullet point has been added here as a replacement for Objective 4.6.
ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: This item focuses on flood hazards, although the benefits may include reductions in infrastructure failures, hazardous material incidents, transportation accidents, and other flood-associated hazards.

Objective 2.8: Promote and assist with wildfire mitigation projects statewide.
Implementation Method:
- MDNR will make use of grants from the USDA Forest Service to help fund local communities in their development of Community Wildfire Protection Plans.
- Since wildfires can be very damaging in large areas of Michigan, scan local plans for hazard mitigation projects to support with technical assistance and/or federal hazard mitigation funds (if applicable).

Committee Priority: HIGH
Completion Target: 2016
Funding: HMA, EMPG, USDA Forest Service
Comments: 2014 status: This is a new objective, added to the 2014 plan in order to more address a greater variety of hazard mitigation activities beyond flooding. Action has already begun on the task in the first bullet point.
BC REVIEW: The evaluation of wildfire mitigation projects must be assessed on a case-by-case basis, because there is not an extensive history of funding for such projects. Yet, the damages from this hazard have been extensive, and therefore new ways to prevent or mitigate its impacts need to be explored. It would not be cost-effective to neglect to make such an effort.
ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: This item focuses specifically on wildfire hazards.

Objective 2.9: Identify and fund appropriate mitigation measures for vulnerable public and private facilities and infrastructure.
Implementation Method:
- Continue to identify, solicit, fund and implement cost-effective, environmentally sound, and technically feasible mitigation projects under the HMA, EMPG and other pertinent programs.
- Per Objective 1.3, fund early warning systems under the HMGP 5% state discretionary set-aside provision and other pertinent programs.
- Per Objective 1.4, fund "safe rooms" within vulnerable public and private structures.
- Per Objective 2.2, further define identified flood vulnerabilities in state owned/operated critical facilities.
- Per Objective 2.4, acquire/remove or relocate all residential and commercial structures currently occupying the floodways of Michigan rivers and streams.
- Per Objective 2.5, acquire/remove, relocate, or elevate the worst NFIP repetitive-loss structures in the state.

Committee Priority: HIGH
Completion Target: 2016
Funding: HMA, EMPG, State Funding (General Fund), Private Funding (Partners TBD), FEMA HMTAP.
Comments: 2014 status: The objective that had previously been referred to under goal 4 is now listed under Goal 2, instead. This change involves the objective's new emphasis upon property protection rather than just agency coordination. Refer to the specific objectives referenced for more details related to each action item. The State of Michigan has funded, or is currently funding, structural and/or non-structural measures under each of the objectives listed in the "Implementation Method" descriptions. The recent advances in the development of many local hazard mitigation plans throughout the state should enable a more efficient process to be used to identify such vulnerabilities for potential funding, but this still requires considerable staff time at MSP/EMHSD. Since 2011, excellent progress has been made in the assembly and creation of digital critical facilities data, for Geographic Information System processing.
BC REVIEW: Although limited federal funds are available for hazard mitigation projects at any given time, such grant funds are only given to subsidize projects that have passed a formal, FEMA-mandated benefit-cost review, thus ensuring that such expenditures are considered to be cost-effective, on a case by case basis.
ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: The general concept of hazard mitigation should be interpreted as including the consideration and alleviation of a full range of natural, technological, and human-related hazards.

Objective 2.10: Promote and assist with severe wind mitigation projects statewide.
Implementation Method:

- Since tornadoes and severe winds are very damaging events in Michigan, scan local plans for hazard mitigation projects to support with technical assistance and/or federal hazard mitigation funds (if applicable).

Committee Priority: HIGH
Completion Target: 2016
Funding: HMA, EMPG
Comments: 2014 status: This is a new objective, added to the 2014 plan in order to more address a greater variety of hazard mitigation activities beyond flooding.
BC REVIEW: The evaluation of wind mitigation projects must be assessed on a case-by-case basis, because there is not an extensive history of funding for such projects. Yet, the damages from this hazard are extensive, and therefore new ways to prevent or mitigate its impacts need to be explored. It would not be cost-effective to neglect to make such an effort.
ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: This item focuses on wind hazards, although the benefits may include reductions in infrastructure failures, transportation accidents, and other hazards.

Objective 2.11: Promote and assist with winter weather mitigation projects statewide.
Implementation Method:

- Since severe winter weather is very damaging in Michigan, scan local plans for hazard mitigation projects to support with technical assistance and/or federal hazard mitigation funds (if applicable).

Committee Priority: HIGH
Completion Target: 2016
Funding: HMA, EMPG
Comments: 2014 status: This is a new objective, added to the 2014 plan in order to more address a greater variety of hazard mitigation activities beyond flooding.
BC REVIEW: The evaluation of winter weather mitigation projects must be assessed on a case-by-case basis, because there is not an extensive history of funding for such projects. Yet, the damages from this hazard are extensive, and therefore new ways to prevent or mitigate its impacts need to be explored. It would not be cost-effective to neglect to make such an effort.
ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: This item focuses on winter hazards, although the benefits may include reductions in infrastructure failures, transportation accidents, and other hazards.

Goal 3

Build Alliances: Forge partnerships with other public safety agencies and organizations to enhance and improve the safety and well being of all Michigan communities.

Objective 3.1: Promote urban forestry and vegetation management programs and initiatives to develop more resilient woodlands, streetscapes, and landscapes in communities throughout Michigan.

Implementation Method:

- Coordination and technical support to local urban forestry programs (professional guidance, training, and education; tree selection, planting, and maintenance; local tree ordinance development; public awareness and education; street and park tree management and planning; community climate adaptation planning; utility vegetation management, awareness, and safety; recognition/certification).
- Conduct periodic educational programs on creating and maintaining a storm-resistant urban forest, targeted at urban forestry programs and local public works agencies.

Comittee Priority: HIGH

Completion Target: 2016

Funding: EMPG, HMA, State Funding (General Fund), Private Funding

Comments: 2014 status: The wording of this objective had been revised by the MCCERCC hazard mitigation committee, and the objective's priority has been raised to HIGH, to better reflect actual programs and their effects. The MDNR Urban and Community Forestry (UCF) program covers the details in the first bullet point, and its recognition/certification aspects include designations such as "Tree City USA," "Tree Line USA," and Certified Arborist. The Michigan Urban and Community Forestry Council (MUCFC) is an advisory committee to state and urban foresters, and works to promote, recognize, and support effective and sustainable management of urban and community forests throughout the state.

BC REVIEW: Urban forestry programs have produced beneficial results in areas determined by local authorities (or utility providers) as being most cost-beneficial. For example, where tree damages are likely to block high-traffic roads, heavily damage nearby property, or interfere with the services provided by critical infrastructure (e.g. electricity, telephones, drain and sewer services), then preventive urban forestry activities have clearly been beneficial. By promoting these types of programs, numerous local residents and programs can more effectively identify the most promising locations and activities where the needs for action greatly exceed the associated costs.

ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: This item is focused on the prevention of technological hazards involving infrastructure failure, whose causes include several natural hazards (such as severe winds and ice storms).

Objective 3.2: Promote floodplain management activities throughout Michigan, increase statewide participation in the National Flood Insurance Program, and ensure that the NFIP policy base accurately reflects the flood hazard threat in Michigan.

Implementation Method:

- Conduct Community Assistance Contacts (CACs) and Community Assistance Visits (CAVs) to promote the NFIP.
- Where feasible, promote participation in the NFIP (as a viable and prudent flood mitigation measure) in all MSP/EMHSD and MDEQ hazard mitigation guidance documents.
- Promote the NFIP at applicable governmental conferences and trade shows.
- Fully participate in all FEMA sponsored promotional events and activities for NFIP recruitment.
- Participation in Map Modernization activities and agency coordination around RiskMap efforts.

Committee Priority: HIGH (Ongoing)

Completion Target: 2016

Funding: EMPG, HMA, CAP, State Funding (General Fund)

Comments: 2014 status: This objective has had its priority increased from MEDIUM to HIGH. The activities identified in the Bullets above are important, ongoing implementation efforts. The MDEQ regularly conducts CACs and CAVs to promote the NFIP and floodplain management as part of its regular work plan under the federal CAP grant with FEMA. The MDEQ also regularly presents information on the NFIP at applicable conferences, training

workshops, trade shows, etc. involving both flood hazard management professionals and elected officials. Both activities will continue to the extent possible. Both the MSP/EMHSD and MDEQ promote NFIP participation in their hazard mitigation guidance publications, and will continue to do so to the extent possible. The activity has become a part of FEMA-approved local hazard mitigation plans throughout Michigan. Progress on flood map updates has been substantial and widespread, through the Map Modernization program. Several state agencies regularly attend local meetings in support of the RiskMap program, to identify hazard vulnerabilities and brainstorm local hazard mitigation activities.

BC REVIEW: Compared with the annual damages caused by flooding each year, the costs of encouraging communities to participate in the NFIP are minor. In addition to making flood insurance available to residents throughout these communities, the NFIP encourages flood mitigation activities designed to reduce future losses. The NFIP also encourages improvements in various policies and practices, designed to increase the long-term safety and security of residents and communities. The costs associated with such improvements are also not primarily borne by just a few agencies or stakeholders, but are widely distributed among a great many public and private stakeholders, in a carefully calculated manner. Thus, the efforts and expense borne by any single participant in this network of stakeholders tends to be appropriate, from a cost-effectiveness standpoint.

ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: This item is focused on flood hazards.

Goal 4

Provide Leadership: Provide leadership, direction, coordination, guidance, and advocacy for hazard mitigation in Michigan.

Objective 4.1: Educate and inform local and state officials, political leaders, the public, and involved professional disciplines about hazard mitigation concepts, programs, processes, and considerations.

Implementation Method:

- Conduct educational seminars where feasible and appropriate.
- Develop, update, and distribute written guidance targeted to specific groups.
- Post relevant information on web pages of the MSP/EMHSD and other agencies.
- Update EMHSD Pub. 207: "Local Hazard Mitigation Planning Workbook."

Committee Priority: HIGH (Ongoing)

Completion Target: 2016

Funding: EMPG, HMA, State Funding (General Fund)

Comments: 2014 status: This objective has had its priority elevated from MEDIUM to HIGH. Ongoing activities include the distribution of guidance materials, handling inquiries with appropriate information, conducting training sessions in multiple locations throughout Michigan, and outreach to interested college and university classes related to urban and regional planning. EMHSD Pub. 207 provides detailed guidance to agencies that develop local hazard mitigation plans, and it needs to be updated to reflect changes in federal planning regulations.

BC REVIEW: This objective is met by distribution (or web-posting) information, by attendance and presentations at meetings and appropriate conferences, or by the submission of materials to newsletters, electronic networks, or targeted publications. All these options entail only low-to-moderate staff, preparation, and travel costs, and the selected approaches can be readily adjusted over time to suit the current staffing and budget situations of the implementing agency. Thus, the benefits of this effort are very likely to outweigh the costs involved.

ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: This item addresses the mitigation of a full range of natural, technological, and human-related hazards.

Objective 4.2: Promote better information flow on hazard mitigation among agencies, between levels of government, and between public and private entities.

Implementation Method:

- Invite other state agencies and private industry to share their concerns, expertise, and ideas with the MCCERCC.
- Regularly publicize the MCCERCC's activities and actions using all appropriate means.
- Promote greater overlap between state and local planning activities.

Committee Priority: HIGH

Completion Target: 2016

Funding: EMPG, HMA, State Funding (General Fund)

Comments: 2014 status: Ongoing activity. Presentations by outside agencies and organizations are included as a regular part of the MCCERCC meeting agenda. MCCERCC meeting notices, meeting notes, and associated reports are made available (via the MSP/EMHSD web site) to a wide array of public agencies and nongovernmental organizations. In addition to the MCCERCC, the primary focus of this objective will include its component agencies such as MSP/EMHSD, which monitors and encourages the development of local hazard mitigation plans throughout Michigan. Although the MHMP is informed by local hazard mitigation plans, steps have been taken with the 2011 and 2014 revisions of MHMP to structure the document so that its structure has more in common with local plans. The forthcoming revision of EMHSD Pub. 207 (see Objective 4.1) will encourage local plans to refer more explicitly to information and objectives in the MHMP.

BC REVIEW: The activities in this objective can be encompassed within current and ongoing staff duties, and therefore should not impose significant additional cost upon the involved agencies. Therefore, the benefits that should be gained from the specified activities can be seen as cost-effective.

ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: This item refers to the mitigation of a full range of natural, technological, and human-related hazards.

Objective 4.3: Continuously revise and enhance the Michigan Hazard Mitigation Plan (MHMP) to ensure it remains current, accurate, relevant, implementable, and in compliance with the federal Disaster Mitigation Act of 2000 and the Emergency Management Accreditation Program (EMAP).

Implementation Method:

- Update the Michigan Hazard Analysis (EMHSD Pub. 103) during or before 2016, as a foundation for updating the MHMP and so as to maintain contact with partnering agencies and assist in more evenly distributing the coordination and feedback process across all parts of the three years available for MHMP update. (The hazard analysis forms approximately half of the content of the MHMP.)
- Integrate relevant data and findings from completed local hazard mitigation plans into the Risk Assessment and other appropriate plan sections.
- Keep the documents posted on the MSP/EMHSD web site, with appropriate staff contact information, so as to be continuously available for public review and feedback.
- Maintain contact with all partnering agencies, and collect information about plan monitoring, project implementation, new conditions, emerging hazards, climatological changes, emergency incidents, and other topics relevant to all types of hazards that could affect Michigan.
- Revise the Michigan Hazard Mitigation Plan to address the appropriate revision period.
- As feasible, establish enhanced collection and analysis systems for the following types of data:
  - Loss estimations for all relevant state owned/operated facilities.
  - Structure counts in floodplains, with particular emphasis on commercial structures.
  - Use of satellite and aerial photographs (now readily available online) for risk assessment purposes.
- Develop the information management capacity to utilize the HAZUS-MH risk assessment tool or to match its capabilities through other means.

Committee Priority: HIGH

Completion Target: 2016 (for hazard analysis, with full plan update due in March 2017)

Funding: EMPG, HMA, State Funding (General Fund)

Comments: Earlier plan editions were approved as federal DMA 2000 compliant on March 29, 2005, March 27, 2008, and March 26, 2011. Plan revisions are required every three years in accordance with the state mitigation plan standards set forth in the federal DMA 2000. 2014 status: The MSP/EMHSD oversaw the completion of a new edition of the Michigan Hazard Analysis in July 2012, with extensive review and input from its partnering agencies, and then oversaw the update of the Michigan Hazard Mitigation Plan by March 2014, when the earlier edition was scheduled to expire. A federal proposal was made to expand the update schedule from a 3-year cycle, to a 5-year cycle, to allow more staff time to be devoted to each update and to synchronize the state schedules with those of local community planning cycles. MSP/EMHSD strongly supports an expanded, 5-year update cycle, but as of this writing, no official confirmation has been received that an expanded schedule has been authorized. The newest MHMP revision benefited greatly from expanded technical analysis capabilities. Internal Geographic Information System enhancements and the expansion of online database and aerial photo archives have led to a substantial improvement in the capacity to analyze hazards. After the 2011 edition of the MHMP was completed, a substantial expansion of the Michigan Hazard Analysis was undertaken, with the assistance of multiple agencies and the MCCERCC. That update was completed and published separately in July 2012, but further revisions and expansion has again been completed for the March 2014 edition of the MHMP. MHMP remains an all-hazard document, and Michigan accreditation under EMAP was successfully obtained. Official EMAP compliance review is scheduled to occur during 2014 and 2015.

BC REVIEW: This objective is a normal part of the work of the MSP/EMHSD and MCCERCC and therefore does not entail any unusual expense for the state. However, since the MHMP is required for the receipt of numerous forms of federal disaster and hazard mitigation assistance, there is clearly a net benefit involved in accomplishing the task. This objective is required by FEMA in order to maintain eligibility for an array of grants, and this type of plan is considered to be a foundational activity for a good emergency management program. Therefore, the efforts of staff are considered to be well-justified in this activity.

ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: The MHMP has continued to cover the fullest array of natural, technological, and human-related hazards, and consideration is continually given to emerging threats that might merit expanded or new detail in this plan.

Objective 4.4: Continuously monitor proposed legislation in Michigan for possible hazard mitigation opportunities and/or implications.

Implementation Method:

- Establish and maintain reporting relationships with state agency legislative liaisons so that mitigation-related aspects of proposed legislation are identified and reported to the MCCERCC.
- Establish and maintain a capability within the MSP/EMHSD to continuously monitor proposed legislation for hazard mitigation implications (using the key word notification mechanism of the Michigan Legislature web site or by other means).
- Establish and maintain reporting relationships with all applicable emergency management and first responder organizations so that mitigation aspects of proposed legislation are identified and reported to the MCCERCC.
- Establish liaison with the Michigan Legislative Service Bureau so that the following are identified and reported to the MCCERCC (to the extent possible): 1) mitigation-related aspects of legislation; and 2) the enactment, revision, and recession of Administrative Rules with mitigation implications.

Committee Priority: MEDIUM
Completion Target: 2019
Funding: EMPG, State Funding (General Fund)
Comments: 2014 Status: MSP now has dedicated staff who keep informed on legislation in Michigan, and initial contact was made by EMHSD staff to prepare for coordination on any forthcoming legislation that has emergency management implications, including hazard mitigation. Although this network link and its accompanying procedures still needs to be solidified, the effort has been bolstered by increased monitoring activities within EMHSD. These activities include extensive monitoring and internal distribution of media items related to MSP, expanded Public Information Officer capacity for the agency, and expanded capabilities for the MIOC. In addition to MSP/EMHSD requests that fire service and other emergency management and first responder organizations make the MSP/EMHSD aware of any proposed legislation that has emergency management implications, internal procedures for sharing information between MIOC, PIO, hazard mitigation planning specialists, and other staff are being put into place. Ideally, all MCCERCC members would similarly expand and connect their own legislative monitoring capabilities to those of MSP/EMHSD, and vice versa. However, it takes time to establish and strengthen these links to become a part of standard operating procedure. The issue of legislation monitoring should be revisited on an annual basis to ensure that all relevant notifications to the MCCERCC are being made in a timely manner.
BC REVIEW: Since certain staff now dedicate more time to this activity, it is hoped that this objective could be accomplished primarily through the development of (de facto) standard operating procedures that increase the level of information and communication among existing staff and agencies that already work with legislative and hazard mitigation concerns, and that the costs of such progress would not be great. In view of the important impact that legislation can have statewide, either to mitigate or to (unknowingly) exacerbate hazard risks and impacts, there should be a clear net benefit to be derived from this effort.
ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: This item refers to the consideration of means to mitigation the impacts of a full range of natural, technological, and human-related hazards.

Objective 4.5: Develop protocols for MCCERCC to solicit, accept, use/expend, and account for private sector donations for hazard mitigation purposes.
Implementation Method:

- Work with the Michigan Department of Technology, Management and Budget (MDTMB) and Michigan Department of State Police (MSP) Management Services to determine the guidelines and parameters for such activities to ensure compliance with state laws, rules and regulations.
- If determined to be feasible and allowable, develop standard protocols for soliciting, accepting, expending, using, managing, reporting on, and accounting for donations (financial and/or in-kind).
- Institutionalize the protocols in the MCCERCC Bylaws to ensure their continued and consistent use.
- As required, develop standardized forms to be used in the conduct of all required transactions (or identify existing forms that can be used).
- Report on the use and final disposition of donations in the MCCERCC Annual Report of Activities document.

Committee Priority: MEDIUM
Completion Target: 2019
Funding: EMPG, State Funding (General Fund)
Comments: 2014 status: The priority for this objective has been lowered to MEDIUM, since limited progress has been made on this objective due to lack of staff and competing work priorities. This objective is still valid and will remain

active for future implementation. This is a key building block for the future success of the MCCERCC when working with the private sector. It is important that a standard and consistent process be used when dealing with private sector entities, not only for appearances sake but also to ensure full compliance with applicable state laws, rules, regulations, and administrative / management mechanisms.
BC REVIEW: This objective would probably just involve the attention and coordination of personnel (possibly within multiple agencies) who have the expertise and time to investigate and compose recommendations on this matter. Since the may be significant additional revenues brought to bear to reduce hazard risks and vulnerabilities through this mechanism, the objective seems to be a highly cost-effective one to pursue.
ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: The general concept of hazard mitigation should be interpreted as including the consideration and alleviation of a full range of natural, technological, and human-related hazards.

~~Objective 4.6: Evaluate flood damage to and caused by failure of sewage handling systems.~~
Implementation Method:
- Convene a subcommittee of subject matter experts from applicable agencies to review this issue in recent flood events and develop solutions to identified problems.
- Implement the solutions where feasible.

Committee Priority: This objective has now been made a part of Objective 2.7.
Comments: The 409 Plan for Federal Disaster 774, October 1986, recommended creating a multi-disciplinary task force to evaluate this issue. This issue has surfaced in more recent flood disasters as well. 2014 status: Little progress has been made on this objective due to lack of staff and competing work priorities. This objective is still valid and will remain active for future implementation, but has been shifted into Objective 2.7, where it should be made a part of ongoing flood mitigation activities.

Objective 4.7: Identify and formally recognize local, tribal, regional, state, or private projects and initiatives that have successfully incorporated hazard mitigation concepts and/or exemplify sound hazard vulnerability reduction strategies.
Implementation Method:
- ~~Identify and review mitigation projects and initiatives annually to determine those that may warrant formal recognition.~~
- MSP/EMHSD will maintain a "Best Practices" document that recognizes hazard mitigation activities in Michigan.

Committee Priority: HIGH
Completion Target: 2016
Funding: EMAP, State Funding (General Fund)
Comments: 2014 status: With regard to bullet 1, the MCCERCC had studied the feasibility of establishing a formal award program for excellent in hazard mitigation and decided that it would be better to team with the Michigan Emergency Management Association (MEMA) to recognize outstanding mitigation efforts through its established mitigation award program. Therefore, at this time there will not be a separate MCCERCC mitigation award program so this action item will be removed from further consideration. With regard to bullet 2, the MSP/EMHSD and the MCCERCC had successfully developed a new publication, "Hazard Mitigation Best Practices: Michigan Success Stories," which identified and recognized outstanding accomplishments in reducing loss of life, property and environmental damage associated with natural hazards in Michigan. This document, MSP/EMHSD Publication 106a (in recognition of its close tie to the MHMP – Publication 106), will be periodically updated. Bullet 2 remains a valid and ongoing action item.
BC REVIEW: The costs of this objective are fairly modest, entailing staff time and input from relevant agencies. Since the "Best Practices" document helps to promote and recognize hazard mitigation efforts, it is expected to result in a net benefit in terms of prompting additional hazard mitigation projects in the future.
ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: The general concept of hazard mitigation should be interpreted as including the consideration and alleviation of a full range of natural, technological, and human-related hazards.

Objective 4.8: Highlight cost savings and other benefits to taxpayers due to mitigation measures that helped reduce future disaster damages.

Implementation Method:

- Regularly write and publish mitigation "success stories / best practices" highlighting the benefits of completed mitigation projects at the state, tribal, and local levels.
- Post the success stories / best practices document on the MSP/EMHSD web site (MCCERCC web page) and submit them to FEMA V for inclusion on the FEMA mitigation web site, as appropriate.
- ~~Consider producing a compendium of Michigan mitigation success stories / best practices and distributing it to the widest array of stakeholders possible.~~
- Include mitigation success stories / best practices in other MCCERCC reports, as appropriate.
- ~~Include mitigation success stories / best practices on the CD produced under Objective 1.1 (statewide mitigation marketing and education campaign) to reach several key stakeholder groups.~~

Committee Priority: HIGH
Completion Target: 2016
Funding: HMA, EMPG, State Funding (General Fund)
Comments: 2014 status: The MSP/EMHSD completed an initial publication, which was made widely available in multiple formats, including online posting. Since this document will be updated in the future, this objective continues to be listed as HIGH priority, even though its initial tasks have been accomplished. Two of the bullets listed in previous MHMP editions have been removed, to reflect progress that has been made and to reflect the greater effectiveness and efficiency of internet posting (rather than CD distribution).
BC REVIEW: This objective may be implemented through a variety of communications media, each with different associated costs. The posting of content on the internet, or in e-mail messages to selected networks or agencies that may help spread the information to others, has proven to be the cheapest method of distributing information, and therefore considered to be the most cost-effective. More expensive options include the use of broadcast media, the production and distribution of printed booklets and CD-ROMs, and having key spokespersons appear at conferences, public events, and in other newsworthy contexts. These are still used when appropriate opportunities are deemed beneficial. Due to the tertiary connection between this objective and the realization of demonstrated direct benefits (from hazard mitigation projects), the choice of promotional techniques usually favors the less expensive options, but all of these outreach activities also produce awareness and preparedness benefits, which add to their overall cost-effectiveness as an appropriate activity to promote.
ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: The general concept of hazard mitigation should be interpreted as including the consideration and alleviation of a full range of natural, technological, and human-related hazards.

Notes for Goals / Objectives:

THE OBJECTIVES UNDER EACH GOAL ARE NOT LISTED IN ORDER OF PRIORITY.

***Note on Committee Priorities:** The MCCERCC Hazard Mitigation Committee re-prioritized these plan objectives in late 2013. Priority rankings are as follows:

HIGH PRIORITY objectives are those slated for implementation during the next 2 years (by 2016), as resources and circumstances allow.
MEDIUM PRIORITY objectives are those slated for implementation during the next 5 years (by 2019), as resources and circumstances allow.
LOW PRIORITY objectives are those slated for implementation over the next 10 years (by 2024), as resources and circumstances allow. (Note: This ranking may also include projects that, because of their nature, will require a multi-year, phased implementation approach. These projects will be labeled "PHASED IMPLEMENTATION" to distinguish them from other projects that received a LOW PRIORITY ranking but that don't require a phased implementation approach.

****Funding Program Acronyms:**
EMPG = Emergency Management Performance Grant;
HMA = Hazard Mitigation Assistance
HMGP = Hazard Mitigation Grant Program;
PDMP = Pre-Disaster Mitigation Program;
FMAP = Flood Mitigation Assistance Program;
RFCP = Repetitive Flood Claims Program;
SRLP = Severe Repetitive Loss Program;
CAP = Community Assistance Program;
HSGP = Homeland Security Grant Program;
CDBG = Community Development Block Grants;
FEMA HMTAP = FEMA Hazard Mitigation Technical Assistance Program;
FEMA MMP = FEMA Map Modernization Program;
USDA = United States Department of Agriculture;
State Funding = Funds appropriated by the Michigan Legislature from the State General Fund; and
Private Funding = Funds provided by a private sector entity for hazard mitigation purposes.

***Notes on Comments for each Objective:** The comments column provides the following information about each objective, as appropriate: 1) the **RATIONALE** for each objective and how it contributes to the overall state mitigation strategy, 2) the **COST-EFFECTIVENESS, ENVIRONMENTAL SOUNDNESS, and TECHNICAL FEASIBILITY** of each objective, and 3) necessary background information to further explain the nature, scope, magnitude and/or intent of the objective.

Cost-effectiveness is described using a text description under the heading "BC REVIEW." Techniques for the review of benefits and costs (including qualitative techniques) is described in the FEMA "How To" guidance document FEMA 386-5, "Using Benefit-Cost Review in Mitigation Planning," dated May 2007. An important part of the BC concept established by FEMA is that the total benefits of a project are to be compared with its total costs, regardless of who receives these costs and benefits. Project costs are usually being considered with respect to the justifiability of applying federal funds. Thus, although a specific project may involve a substantial federal subsidy, the federal grant usually is not seeking a net benefit for its own budget, but rather is seeking an overall collective benefit, in the form of reduced damages and costs for all who may be affected or at-risk (not just the government).

Environmental soundness and technical feasibility are listed as either "Y" (yes) or "N" (no). Finally, some comments are added to clarify (or confirm) how the hazard mitigation objectives address a full array of natural, technological, and human-related hazards ("Multi-hazard").

Compendium of Addressed Objectives

(The following objectives have either been completed or removed from further consideration due to non-feasibility, consolidation, or other reason.)

Objective (in 2005 MHMP)	Implementation Method	Completed or Removed?	Date Addressed	Funding Source	Comments / Rationale
1.5: Amend the State Fire Safety Code and code enforcement program to include all places of public assembly and congregation.	• Study the feasibility of amending the Code. • Amend the Code (if feasible). • Develop and fund a uniform statewide code enforcement program.	REMOVED	N/A	State Funding (General Fund)	BC REVIEW: N/A ENVIR SOUND: Y TECH FEASIBLE: Y This objective was removed from the plan because it is not consistent with the hazard base currently addressed in the plan. State Fire Safety Code issues pertain primarily to the structural fire hazard, which is not addressed in the plan at this time. If the plan expands in future revision cycles to include structural fire and other technological hazards, this objective may be reinstated.
2.1: Integrate hazard mitigation into the comprehensive planning process at the local and regional levels.	Establish contact with the State Legislative Committee involved in preparing the "Coordinated Planning Act" to encourage the following: • Incorporate hazard mitigation into the comprehensive planning process at the local and regional levels by making it a required plan element. • Incorporate hazard area classifications into standard zoning classifications used in Michigan. • Permit county overlay zoning of designated hazardous river and stream corridors, hazardous transportation corridors, and intercommunity hazardous areas. • Require that County Drain Commissioners be included in the review and approval or disapproval of all land use change proposals – to include condominiums, development site plans, and mobile home parks (in addition to the existing review requirement for land subdivisions. • Require cross jurisdictional hydrologic planning between legal entities within watershed units.	SUBSTANTIALLY COMPLETED	2006	State Funding (General Fund)	Background: Several versions of this Act had been introduced in the Michigan Legislature in recent years but it was not enacted due to widely differing views on land use and local control issues. In 2003, Governor Granholm and Michigan legislative leaders convened the Michigan Land Use Leadership Council (MLULC) to conduct a comprehensive review of Michigan's land use and land development policies and their impact on the state's economy and quality of life. One of the recommendations of the MLULC was the consolidation and modernization of Michigan's antiquated planning and zoning enabling laws. The MHMCC made several specific recommendations to the MLULC on this issue in a letter dated July 15, 2003. On July 1, 2006, Michigan's three zoning enabling acts (one each for cities and villages, townships, and counties) were officially repealed and combined into one new statute, the Michigan Zoning Enabling Act (2006 PA 110). Although it is difficult to determine if any of the MHMCC recommendations were considered during the deliberations for the Act, the fact that it passed is a great step forward. The new Zoning Enabling Act appears to provide sufficient flexibility and regulatory framework to allow communities to effectively use comprehensive planning and zoning to reduce their natural hazard risk and vulnerability. (**Preparer's Notes:** Although the Zoning Enabling Act does not specifically address the three issues identified in the Hazard Mitigation Strategy for Federal Disaster 1128 (yellow highlighted bullet points in the far left column), there is little likelihood that these issues will be included in amended versions of the Zoning Enabling Act – at least in the foreseeable future – given the difficulty required to get even the basic consolidation and modernization of the Act in the first place. 2006 PA 110 was subsequently amended by 2008 PA 12 on February 29, 2008. No changes regarding hazard risk / vulnerability reduction. At the time of this writing, a companion bill to unify Michigan's planning enabling laws had been presented to the Governor for signature.) BC REVIEW: N/A ENVIR SOUND: Y TECH FEASIBLE: Y

Compendium of Addressed Objectives

(The following objectives have either been completed or removed from further consideration due to non-feasibility, consolidation, or other reason.)

Objective (in 2005 MHMP)	Implementation Method	Completed or Removed?	Date Addressed	Funding Source	Comments / Rationale
2.3: Implement appropriate mitigation measures to protect state owned / operated critical facilities and infrastructure from acts of sabotage and terrorism.	Possible mitigation measures include, but are not limited to: • Developing risk / vulnerability assessments of potential sabotage / terrorism threats. • Developing plans, strategies and procedures for mitigating identified vulnerabilities. • Enhancing personnel capabilities through site safety training, better equipment, improved information dissemination, increased numbers of personnel, etc. • Hardening of facilities to include design, construction and structural enhancements to prevent damage and the potential for injury or loss of life (i.e., stronger / fire resistant materials; use of shatterproof / glazed glass; better egress routes; reduced points of entry; increased "buffer" zones; etc.) • Physical security enhancements to include fencing, barriers, locking doors, lighting, cameras / monitors, motion detectors, alarms, computer firewalls, redundant security / communication systems, etc. • Security screening enhancements to include bio-threat detectors, metal detectors, x-ray machines, plastic explosive detectors, electronic ID card systems, optical / fingerprint scanners, etc.	REMOVED	ONGOING	HSGP State Funding (General Fund)	Ongoing effort, under the umbrella of the Michigan Homeland Security Strategy and in conjunction with the Michigan Homeland Security Preparedness Committee, Michigan Homeland Security Advisory Council, Michigan Homeland Protection Board, the MSP/EMHSD, and appropriate state agencies. With this homeland security structure in place, this objective would no longer fall under the purview of the MCCERCC. BC REVIEW: N/A ENVIR SOUND: Y TECH FEASIBLE: Y
2.4: Amend the State Construction Code to include, where appropriate, hazard mitigation measures designed to enhance wind, flooding, snow load and fire protection provisions.	• Establish a new statewide building code based on the national consolidated code.	COMPLETED	2000	State Funding (General Fund)	New statewide code established and implemented under 1999 PA 245. The code has adequate provisions for wind, flooding, snow loads and fire protection.
2.6: Amend Part 31 of the State Floodplain Regulatory Authority to address the "grandfather" clause that allows continued floodway occupation as long as the size of the structure is not increased.	• Amend the Part 31 Rules.	REMOVED	ONGOING	EMPG CAP State Funding (General Fund)	Objective merged (with old Objective 2.6, current Objective 2.4) to include all desired modifications to the Part 31 Rules.

Compendium of Addressed Objectives

(The following objectives have either been completed or removed from further consideration due to non-feasibility, consolidation, or other reason.)

Objective (in 2005 MHMP)	Implementation Method	Completed or Removed?	Date Addressed	Funding Source	Comments / Rationale
2.8: Incorporate hazard mitigation factors into the design review process for construction or major modification of all state owned / operated critical facilities.	• As part of the MHMP revision process, identify state owned / operated critical facilities occupying floodplains, floodways, subsidence areas, high risk erosion zones, earthquake zones and other known, location-specific natural and technological hazard areas. • As part of the MHMP revision process, estimate potential losses to state owned / operated critical facilities for all relevant natural, technological and human-caused hazards. • Based on the results of the MHMP Risk Assessment process, conduct detailed follow-up studies of vulnerable facilities to identify the most appropriate mitigation measures for each facility, given its level of vulnerability, potential losses, facility design and function, etc. Specifically address the following identified concerns: ➢ Determine the first floor elevations of facilities in identified floodplains and other potential flood prone areas. Determine if facilities should be flood proofed, elevated, or relocated, or if drainage should be improved, as the most appropriate mitigation option. ➢ More precisely identify facilities that are vulnerable to subsidence by conducting site-specific geological surveys to determine the presence of abandoned and unmapped underground mines. • Based on the results of these detailed studies, select the most appropriate mitigation measures and strategies for each facility in order to minimize future disaster damage. • Implement identified measures and strategies where possible, based on available resources. • Through the MDTMB representative on the MHMCC, encourage state agency personnel involved in the design review process for future construction or major modification of state facilities to advocate for hazard mitigation measures whenever practical. • Revise and enhance the State Flood Hazard Mitigation Plan (Executive Order 1977-4) to prevent, where possible, the locating of state facilities in floodplains, floodways or other known hazardous areas.	SUBSTANTIALLY COMPLETED	2005	EMPG State Funding (General Fund)	The MHMCC Legislative and Special Projects Committees, working with the Governor's Office, developed Executive Directive 2001-5 (signed on September 11, 2001) which directs the MDEQ to work with the MHMCC and other state agencies to develop a statewide, interagency flood mitigation strategy to assure compliance with Executive Order 1977-4. The new Directive will re-focus state agency efforts on sound floodplain management practices in the coming years. (Completed) State owned / operated critical facilities identified as part of the 2004 MHMP revision. (Completed) Potential natural hazard losses estimated for state owned / operated critical facilities as part of the 2004 MHMP revision. (Completed) A detailed follow-up study of vulnerable state owned / operated critical facilities would help to determine the types of "brick and mortar" projects that would be required to permanently reduce any identified facility vulnerabilities to flooding. However, such a study would absolutely require a FEMA HMTAP contract (at 100% federal share) in order to be conducted and properly analyzed by the next scheduled plan revision (2011). This study may be undertaken as time, circumstances, and resources permit. Refer to new Objective 2.6. (Note: no state owned / operated critical facilities are located within high-risk erosion zones, and the potential losses to state owned / operated facilities from earthquake were determined to be negligible. No follow-up mitigation actions are required for these two hazards.) For follow-up studies and planning: BC REVIEW: N/A ENVIR SOUND: Y TECH FEASIBLE: Y For selected mitigation actions, based on the study results: BC REVIEW: + (only cost-effective actions will be implemented) ENVIR SOUND: Y (only environmentally sound actions will be implemented) TECH FEASIBLE: Y (only technically feasible actions will be implemented)

Compendium of Addressed Objectives

(The following objectives have either been completed or removed from further consideration due to non-feasibility, consolidation, or other reason.)

Objective (in 2005 MHMP)	Implementation Method	Completed or Removed?	Date Addressed	Funding Source	Comments / Rationale
2.11: Study methods to map all floodplains in Michigan to current FEMA / MDEQ standards.	• Maximize MDEQ participation in FEMA's Map Modernization Program. • Maximize local participation in the Cooperating Technical Partner (CTP) Program with the MDEQ.	COMPLETED	2007	FEMA MMP CAP State Funding (General Fund)	The MDEQ is fully engaged in the FEMA Map Modernization Program and the CTP. These efforts should yield updated floodplain maps statewide within the next few years. BC REVIEW: N/A ENVIR SOUND: Y TECH FEASIBLE: Y
2.20: Encourage and provide technical assistance to communities to use CDBG funds for implementing water and sewer freeze resistance measures.	• Work with the Michigan CDBG Program to determine which types of projects would be eligible for funding consideration under the Rebuild Michigan and other similar programs. • Provide that information to communities statewide via informational letter, web posting, or other appropriate method. • Establish a monitoring system with the CDBG Program to determine the number of freeze related projects that have been funded.	COMPLETED	1996	CDBG EMPG State Funding (General Fund)	Reliable water and sewer infrastructure is vital to community economic development and job creation and retention. CDBG funds were used to implement 12 water and sewer infrastructure freeze protection projects within the declared area for Federal Disaster 1028. The total CDBG investment in these ground freeze mitigation projects was $5.7+ million. BC REVIEW: + ENVIR SOUND: Y TECH FEASIBLE: Y
2.22: Develop hazard mitigation plans (in coordination with local comprehensive plans if possible) in all local emergency management program jurisdictions.	• Develop and distribute planning guidance. • Provide technical assistance as needed. • Collect and compile pertinent data related to the planning effort. • Provide direct assistance in writing plans as needed. • Review and certify completed plans. • Submit plans to FEMA for final certification.	SUBSTANTIALLY COMPLETED	2008	HMGP FMAP PDMP EMPG	HMGP Project under Federal Disaster 1346. PDMP and FMAP funds also being used in plan development. Goal: develop local mitigation plans that cover all counties and major municipalities in Michigan. Major work project for 2002-2008. (Ongoing) BC REVIEW: N/A ENVIR SOUND: Y TECH FEASIBLE: Y
3.4: Increase the statewide NFIP policy base to more accurately reflect the flood hazard threat in Michigan.	• All implementation methods listed under Objective 3.3 are also valid under this Objective.	CONSOLIDATED	N/A – ONGOING ACTIVITY	EMPG HMGP FMAP CAP State Funding (General Fund)	Combined with Objective 3.3. Generally, the MDEQ targets its NFIP promotional activities at those communities that have the greatest flood risk. These flood prone communities are a higher priority for promotional activities than are communities with less of a flood risk. (Ongoing) BC REVIEW: N/A ENVIR SOUND: Y TECH FEASIBLE: Y

Compendium of Addressed Objectives

(The following objectives have either been completed or removed from further consideration due to non-feasibility, consolidation, or other reason.)

Objective (in 2005 MHMP)	Implementation Method	Completed or Removed?	Date Addressed	Funding Source	Comments / Rationale
3.6: Identify and implement mitigation measures that could reduce or eliminate the threats to life and property from hazardous material fixed site and transportation accidents.	• Study possible methods and mechanisms for expediting the completion of SARA Title III off-site response plans required for each Section 302 site. • Develop strategies to integrate local emergency management planning and SARA Title III hazardous material response planning into local comprehensive planning efforts. (See Goal 2 – Reduce Property Damage – for additional information on this activity.) • Consider integrating local hazardous material planning efforts (via the LEPCs) into the "Michigan Safety First Community" initiative described in Objective 3.1. • Develop strategies for assisting LEPCs in proactively examining 302 sites to reduce chemical inventories (where feasible) and the resultant risks to human life and property.	REMOVED (NOT WITHIN PURVIEW OF PLAN)	N/A	EMPG State Funding (General Fund)	Federal HMEP and HSGP funding has been used to facilitate the completion of some SARA Title III Section 302 plans. Approximately 75% of the 2,749 Title III Section 302 sites in Michigan have a completed offsite response plan. Many of those completed plans will need to be updated over the next several years. (Ongoing) BC REVIEW: N/A ENVIR SOUND: Y TECH FEASIBLE: Y This objective was removed from the plan because it is not consistent with the hazard base currently addressed in the plan. If the plan expands in future revision cycles to include hazardous material incidents and other technological hazards, this objective may be reinstated.
4.3: Develop efficient, effective, fair and impartial hazard mitigation project identification, solicitation, review, prioritization and selection processes.	• Develop a project identification and solicitation system that can be tailored to meet the needs of each disaster situation, and that results in the submittal of an adequate number of high quality mitigation projects. • Develop a mitigation resource matrix / manual so that all potential and appropriate funding programs are considered when prioritizing projects. • Develop a project prioritization system that includes current and relevant review criteria and clear-cut scoring options.	COMPLETED	2008	EMPG HMGP FMAP PDMP State Funding (General Fund)	The MCCERCC and MSP/EMHSD have developed fair and impartial project identification, solicitation, review, prioritization and selection processes related to the HMGP, FMAP, PDMP, RFCP, and SRLP. The "Funding Sources for Hazard Mitigation" guidance document (MSP/EMHSD Publication 207A and a supplement to the Michigan Hazard Mitigation Plan) was updated for the 2008 MHMP revision. (This voluminous publication can be used to identify possible alternative funding sources for hazard mitigation projects.) BC REVIEW: N/A ENVIR SOUND: Y TECH FEASIBLE: Y
4.4: Promote multi-objective results on all hazard mitigation projects and initiatives.	• Make multi-objective results one of the criteria used in the prioritization of projects for funding under the HMGP, PDMP, FMAP, RFCP, and SRLP.	COMPLETED	2008	HMGP EMPG FMAP PDMP State Funding (General Fund)	The achievement of multiple objectives is now institutionalized under the review criterion "Consistent with Other Initiatives?" in the prioritization of projects for funding under the HMGP, PDMP, FMAP, RFCP, and SRLP.

Compendium of Addressed Objectives

(The following objectives have either been completed or removed from further consideration due to non-feasibility, consolidation, or other reason.)

Objective (in 2005 MHMP)	Implementation Method	Completed or Removed?	Date Addressed	Funding Source	Comments / Rationale
4.8: Develop a staffing pattern for adequately addressing state and local hazard mitigation functions, and pursue funding of needed mitigation positions.	• Prepare and submit staffing plans for funding under HMGP State Management Costs, as disasters occur. • Prepare and submit staffing plans for funding under PDMP State Management Costs, as annual funding cycles occur. • Develop and maintain mitigation position descriptions that accurately reflect the nature, scope and magnitude of work required in each position. • Identify (and pursue, as appropriate) other funding sources that could be used to fund hazard mitigation positions.	COMPLETED (BUT REQUIRES ONGOING MAINTENANCE TO SUSTAIN CAPABILITY)	N/A – ONGOING	HMGP and PDMP Management Costs EMPG FMAP State Funding (General Fund) Private Funding (Partners TBD)	The MSP/EMHSD has successfully used HMGP State Management Cost funding in the past to staff needed positions related to grants management, planning and administrative support. Those positions were initially limited term positions but have all been converted to permanent positions, providing the long term continuity required to adequately address and sustain hazard mitigation functions on a permanent basis. It is imperative that stable, continuous funding sources be identified to provide for the continuation of these hazard mitigation positions. Otherwise, staff may be re-assigned to other functions within the division. BC REVIEW: N/A ENVIR SOUND: Y TECH FEASIBLE: Y
4.14: Increase the proportion of full-time, paid professional firefighters within the state fire service.	• Consider legislation creating a state fire fund to provide supplemental funding to hire and train full-time firefighters. • Study the feasibility of establishing more full-time public safety officer positions within Michigan local jurisdictions.	REMOVED (NOT WITHIN PURVIEW OF PLAN)	N/A	State Funding (General Fund)	(Note: Public safety officers are generally combination EMTs, police officers, and firefighters.) BC REVIEW: N/A ENVIR SOUND: Y TECH FEASIBLE: Y This objective was removed from the plan because it is not consistent with the hazard base currently addressed in the plan. The issue of full-time fire service staffing pertains primarily to the structural fire hazard, which is not addressed in the plan at this time. If the plan expands in future revision cycles to include structural fire and other technological hazards, this objective may be reinstated.
4.17: Study the floodplain service program of MDEQ to determine appropriate staffing levels, given current and projected service requests.	• MDEQ budgetary process. • Federal CAP budgetary process.	COMPLETED (BUT REQUIRES ONGOING MAINTENANCE TO SUSTAIN CAPABILITY)	N/A – ONGOING	CAP State Funding (General Fund)	Current and projected service requirements related to floodplain management will be considered as part of the normal MDEQ and CAP budgetary processes. Requirements for additional staff will be addressed within those two separate, yet related processes. BC REVIEW: N/A ENVIR SOUND: Y TECH FEASIBLE: Y

Compendium of Addressed Objectives

(The following objectives have either been completed or removed from further consideration due to non-feasibility, consolidation, or other reason.)

Objective (in 2008 MHMP)	Implementation Method	Completed or Removed?	Date Addressed	Funding Source	Comments / Rationale
Objective 1.5: Establish / enhance anchoring requirements for oil, gasoline, and propane tanks, and paint, chemical barrels in known flood hazard areas.	• Study the feasibility of amending State Administrative Rules to include comprehensive anchoring requirements for all land uses in known flood hazard areas. • Amend the Administrative Rules (if feasible).	REMOVED	N/A	State Funding (General Fund)	2011 status: This objective is not feasible given current and projected future resource environments. It will be tabled for the foreseeable future. Refer to the "Compendium of Addressed Objectives" table. BC REVIEW: The anchoring of tanks and barrels is relatively cheap, and under flood conditions may prevent the complete loss of the substances they contain, as well as a reduction in potential liability from damages that may be caused by loose tanks and barrels as they float away. When the costs of environmental contamination, cleanup, and liability are compared with the relatively cheap costs of anchoring, the cost-effectiveness of this measure seems apparent. ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: This item is relevant for technological hazards.
Objective 1.7: Establish / enhance state disclosure provisions for flood prone areas (require the status of all buildings located in floodplains be disclosed as a condition of financing from a financial institution).	• Study the feasibility of legislation to strengthen disclosure provisions under state law (Seller Disclosure Act, 92 PA 1993, as amended). • Consider within that legislation a provision to prohibit construction of public buildings within the floodplain except those required to meet specific needs within the floodplain.	REMOVED	N/A	State Funding (General Fund)	The 1994 Flood Insurance Reform Act requires banks to ensure that flood insurance policies are issued on all structures on which they write loans that are located in the floodplain. The seller of the structure must file a disclosure form with the realtor. However, this requirement only applies to federally insured banks and does not apply to land contracts or state chartered banks. Therefore, disclosure provisions do not apply to all financial transactions involving homes located in floodplains. In addition, if an area is not mapped for floodplains, then no disclosure of flood liability can be required. A further problem lies in the current version of the disclosure forms that permit an "I don't know" answer to the question of location in a floodplain. 2011 status: This objective is not feasible given current and projected future resource environments. It will be tabled for the foreseeable future. Refer to the "Compendium of Addressed Objectives" table. BC REVIEW: Although this is more of a regulatory proposal than an action with a specific associated cost, the benefits should be substantial in promoting an awareness of (and therefore mitigation of) flood risks, which could no longer simply be passed, *caveat emptor*, to a different (and unsuspecting) property owner. Although there would be administrative costs associated with such regulations, real estate buyers would be more likely to purchase property at a price that better reflects its true value and thus realize substantial savings and benefits for property buyers. At this current time, when Michigan faces the risk of a net population loss, a provision which provides reassurance to property buyers may also be a useful mechanism to use in trying to attract new residents. ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: This item is specifically directed toward flood awareness and mitigation, but since flooding can lead to the secondary impacts of infrastructure failure, transportation accidents, and hazardous material incidents, and since flood conditions can impede the ability to respond to fires, storms, and other emergency events, flood awareness and prevention efforts can be considered to also serve as prevention for the secondary impacts that a flood can cause.
Objective 1.8: Study the feasibility of requiring all manufactured homes to be tied down (structurally anchored), not just those in designated floodplains, to prevent wind and water rollovers.	• Work with the MDLEG Manufactured Housing Commission to study the feasibility of such a proposal. • Assist in promulgating rules to require universal tie downs (if feasible).	REMOVED	N/A	State Funding (General Fund)	New manufactured homes are required to have an anchoring system installed at the time of building. However, older, existing mobile / manufactured homes are not covered under this requirement. 2011 status: This objective is not feasible given current and projected future resource environments. It will be tabled for the foreseeable future. Refer to the "Compendium of Addressed Objectives" table. BC REVIEW: Part of the feasibility study could include a consideration of overall costs (to private owners, park operators, insurance agencies, and any other involved stakeholders) compared to the expected benefits of substantially reduced property damage amounts. ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: This particular item is aimed at specific natural hazards, although it is worth noting that any actions that protect people's homes has the corollary effect of maintaining the capacities for in-place sheltering and protection that may be appropriate for certain types of technological emergencies, such as those involving a radiological or chemical release. In addition, by maintaining the integrity of residential units, the capacity of the state to house its residents, plus any evacuees from a national emergency event (i.e. Hurricanes Katrina and Rita in 2005) is maintained and bolstered. Every residential unit left intact after a disaster means a lessened number of residents that may need sheltering, and may also result in an additional capacity to house those who have been displaced from their own homes.

Compendium of Addressed Objectives

(The following objectives have either been completed or removed from further consideration due to non-feasibility, consolidation, or other reason.)

Objective (in 2008 MHMP)	Implementation Method	Completed or Removed?	Date Addressed	Funding Source	Comments / Rationale
Objective 1.9: Revise the Michigan Hazard Analysis to address the years 2006-2008.	• Collect, compile, analyze and synthesize hazard data for the period 2006-2008. Incorporate hazard data from local hazard analyses / risk assessments and mitigation plans as appropriate. • Revise the document format and content as required to reflect the state's current hazard base, state / national / international conditions, and changes in state / federal laws, regulations, policies, programs, and funding. • Develop and distribute the revised document. • Incorporate findings into the 2011 revision to the Michigan Hazard Mitigation Plan. (Note: revised plan must be federally approved by March 28, 2011.) • Note: Implementation of this project is contingent upon additional state planning staff for the MSP/EMHSD.	COMPLETED	2010	EMPG, HMGP, PDMP, State Funding (General Fund)	2011 status: This objective has been completed for the specified time period. Refer to the "Compendium of Addressed Objectives" table. BC REVIEW: The regular updating of Michigan's hazard mitigation documents is clearly cost-effective not only because of the usefulness of these documents to emergency management programs throughout the state, but because of the substantial amount of federal funding whose availability is contingent upon maintaining these documents to the required standards. The staff time of key workers in State government, plus those external parties who review and provide input into the process, is offset by federal support for such planning efforts, and by saving other agencies the substantial resources (and redundancy) that would be involved were they to all independently investigate and analyze the subjects from scratch, on their own. ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: The Michigan Hazard Analysis describes all significant hazards known to affect Michigan, from an emergency management perspective. The Michigan Hazard Analysis document, previously published in 2006, has had its natural hazard sections updated and published in the 2008 Michigan Hazard Mitigation Plan. In 2010, all the remaining hazard sections were updated for the EMAP Hazard Analysis Annex to the Michigan Hazard Mitigation Plan. These are currently being consolidated into the 2011 Michigan Hazard Mitigation Plan update, in which this objective will be revised to refer to the publication of these updated sections as a separate Michigan Hazard Analysis document during 2011.
Objective 1.10: Develop and widely publish a recommended listing of "safety / preparedness gifts" that could be purchased for Christmas, birthdays, and other special occasions, to improve personal and family safety and preparedness in a disaster or emergency.	• Establish a committee of emergency management and human service agencies to develop a list based on current family preparedness guidance. • Identify private sector partners that might be interested in assisting with mass dissemination of the list.	COMPLETED	2010	HMGP, PDMP, Private Funding	The list could be published in paper format, posted on the MSP/EMHSD web page, advertised in the media, and distributed at home centers and other retail outlets. The list would support and expand upon FEMA's Family Protection concept (being self-sufficient for 72 hours). The list could be sent out under cover of a press release during the Christmas shopping season and at other appropriate times during the year. 2011 status: This objective has effectively been addressed by the MSP/EMHSD "Do One Thing" and "Be Prepared Be Safe" preparedness initiatives (and by link, the federal "Ready.Gov" web site), which advocate and provide guidance for the purchase and stockpiling of safety / preparedness gifts as a basic family preparedness measure. No further activity is required on this objective. Refer to the "Compendium of Addressed Objectives" table. BC REVIEW: Given the ability to cheaply distributed such information electronically, the costs involved in producing such a list would mainly amount to some staff time on the part of selected state employees (or the adaptation, with permission, of some similar listing that may already have been produced by another agency). As with other forms of public education and awareness building on the subjects of safety, preparedness, and hazard mitigation, the expense involved in accomplishing this task would likely be considered justifiable if even a single death was prevented as a result of such a campaign. ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: The recommended listing would not be limited only to natural hazard preparedness, so this item is appropriate for addressing all hazards.

Compendium of Addressed Objectives

(The following objectives have either been completed or removed from further consideration due to non-feasibility, consolidation, or other reason.)

Objective (in 2008 MHMP)	Implementation Method	Completed or Removed?	Date Addressed	Funding Source	Comments / Rationale
Objective 2.2: Develop, construct, and operate (in conjunction with other appropriate entities) a Michigan "Safety House" demonstration model to provide a training and information focal point for builders, building officials, code enforcement officers, engineers, community planners, public works agencies, drain commissioners, and the public on safe, sustainable and disaster resistant building materials and construction techniques.	• Revise existing MSP/EMHSD concept paper for use as an educational and "selling" tool for potential partners in the venture. • Identify and approach potential venture partners to gain support and commitment for the concept. • Determine size and scope of demonstration model (i.e., full-size structure vs. smaller scale demonstration model) per the options discussed in the concept paper. • Determine construction and operational costs. • If feasible, develop a plan of action for constructing the model. • If a full-size structure is built, develop a plan of action for maintenance and operation of the facility.	REMOVED	N/A	HMGP, PDMP, Private Funding	MSP/EMHSD developed the original concept paper during FY 01. A full-size facility could serve as a focal point for hazard mitigation activities within the State of Michigan. 2011 status: No additional progress has been made on this objective due to lack of staff and competing work priorities. This objective is not feasible given current and projected future resource environments. It will be tabled for the foreseeable future. Refer to the "Compendium of Addressed Objectives" table. BC REVIEW: A model will help to demonstrate the feasibility and benefits of disaster-resistant construction. If such construction can be encouraged and its implementation increased "in the field," then the costs of developing the model will pay off in the increased durability and damage-resistance of actual structures that eventually experience threatening conditions. ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: The "disaster resistant" concept is relevant for all types of hazards.
Objective 2.3: Amend Part 31 of the State Floodplain Regulatory Authority to address 1) concerns pertaining to permits for filling or construction within the floodplain of inland lakes, and 2) the "grandfather" clause that allows continued floodway occupation as long as the size of the structure is not increased.	• Study the feasibility of amending the Part 31 Rules. • Amend the Part 31 Rules (if feasible).	COMPLETED	N/A – ONGOING	EMPG, CAP, State Funding (General Fund)	Part 31 rules have been rewritten and are undergoing internal and external review for possible further modification. The current draft of these rules addresses construction in floodplains of lakes as well as structures in floodways that are currently protected by the grandfather clause. (Ongoing) 2011 status: This objective has effectively been addressed by the above-referenced Administrative Rules. No additional amendments are likely or planned for the foreseeable future. Refer to the "Compendium of Addressed Objectives" table. BC REVIEW: Although certain costs may be incurred by particular persons or parties, the intention is to realize much greater collective benefits, even if such circumstances turn out to require case-by-case evaluation. ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: This item is aimed toward the flood hazard, but can also help to alleviate secondary impacts of flooding that may involve other types of hazards (e.g. infrastructure failure, public health emergencies, etc.).

Compendium of Addressed Objectives

(The following objectives have either been completed or removed from further consideration due to non-feasibility, consolidation, or other reason.)

Objective (in 2008 MHMP)	Implementation Method	Completed or Removed?	Date Addressed	Funding Source	Comments / Rationale
Objective 2.4: Study methods to incorporate hazard mitigation considerations into the design of new and substantially improved public infrastructure to ensure disaster-resistance and structural integrity.	• Conduct a comprehensive study of federal and state regulatory mechanisms related to the design, engineering and construction of public infrastructure. • Study the feasibility of amending state codes, standards, rules and permitting processes for public infrastructure to incorporate or enhance disaster-resistant practices. • Amend codes, standards, rules, and permitting processes (if feasible). • Develop and adopt minimum standards for drain design and construction as part of the effort to revise the State Drain Code.	CONSOLIDATED	N/A – ONGOING	HMGP, State Funding (General Fund)	Possible areas of emphasis include (1) Electric utility infrastructure – wind, ice, and snow resistance, (2) Water and sewer infrastructure – ground freeze resistance, (3) Drain infrastructure – storm water carrying capacity, damage resistance. 2011 status: This objective is being addressed by the statewide mitigation marketing / education project described in Objective 1.1; therefore, this objective will be eliminated. Refer to the "Compendium of Addressed Objectives" table. BC REVIEW: Staff and coordination time will be required, to explore the benefits of hazard-oriented infrastructure improvements. Since this infrastructure tends to serve many thousands of persons, however, it can be assumed that in at least some communities, a favorable set of benefits would be realized that offsets the costs of the redesign and improvement activities. ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: This item is not limited to natural hazards. For example, substantial consideration has been given in recent years to the "hardening" of critical facilities and infrastructure against terrorism and sabotage.
Objective 2.7: Amend Part 315 of the Natural Resources and Environmental Protection Act to regulate development downstream of a dam through analysis of the dam's hydraulic "shadow."	• Study the feasibility of amending Part 315 of the Act. • Amend Part 315 of the Act (if feasible).	REMOVED	N/A	CAP, State Funding (General Fund)	There are no current restrictions to occupation of areas below a dam. Amendments may be needed in the Dam Safety Act to identify that there is a hydraulic shadow below each dam and that development therein is at risk in case of a dam failure. At present, local zoning authority can prohibit building in the hydraulic shadow but that does not always occur. An alternative to the legislative amendment would be a vigorous educational campaign targeted at local zoning administrators and other community officials. (Ongoing) 2011 status: Additional progress on this objective has been slowed due to lack of staff, competing work priorities, and political and fiscal realities. This objective is not feasible given current and projected future resource environments. It will be tabled for the foreseeable future. Refer to the "Compendium of Addressed Objectives" table. BC REVIEW: Although some decline in property values may be incurred in certain locations, there would certainly be higher-risk locations for which any such decline (which may be difficult to definitively measure) is clearly offset by a lessened degree of vulnerability. ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: This item is specific to the dam failure hazard, and dam structures themselves may be considered a technological hazard, such as infrastructure failure.
Objective 2.8: Study the implications of instituting statewide watershed management to enhance local and state flood management efforts in Michigan.	• This issue is being considered as part of the overall effort to amend the state planning enabling legislation (the "Coordinated Planning Act"). • Consider conducting a separate study of this issue, in conjunction with the Michigan Association of Regions, the Michigan Association of Planning, and other appropriate professional groups.	REMOVED	N/A	HMGP, FMAP, CAP, State Funding (General Fund)	Watershed management / cross jurisdictional hydrologic planning between legal entities within watershed units is currently being studied as part of the overall effort to enact the Coordinated Planning Act. However, there is no guarantee that this issue will be fully addressed or addressed at all in that larger effort. Therefore, it may be necessary to conduct a separate study on this issue to ensure that it is fully considered. 2011 status: Additional progress on this objective has been slowed due to lack of staff, competing work priorities, and political and fiscal realities. This objective is not feasible given current and projected future resource environments. It will be tabled for the foreseeable future. Refer to the "Compendium of Addressed Objectives" table. BC REVIEW: Although a new program may at first appear to entail significant expense, it is likely that efficiencies would be realized by being handled at the state level. The nature of watersheds automatically makes them a multi-jurisdictional responsibility that may take some trouble to coordinate and act upon at the local level, especially if funding and staff time is found to be in short supply. ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: Watershed management includes the alleviation of multiple types of secondary effects from flooding.

Compendium of Addressed Objectives

(The following objectives have either been completed or removed from further consideration due to non-feasibility, consolidation, or other reason.)

Objective (in 2008 MHMP)	Implementation Method	Completed or Removed?	Date Addressed	Funding Source	Comments / Rationale
Objective 2.9: Conduct a study of Michigan's land character and its influence on storm water runoff – to facilitate the development of a land coverage formula for Michigan based on soil character.	• Digitize soil surveys of all Michigan counties to show and determine soil erosion potential and soil water holding capacity. (From this effort, a formula can be developed to calculate the maximum recommended land coverage for impervious surfaces. Soil characteristics, slopes and vegetation types will be considered in the development of this methodology.)	REMOVED	N/A	HMGP, PDMP, State Funding (General Fund)	This project was initiated with two HMGP projects under Federal Disasters 1128 and 1181 ($442,853 in project investment to date). Soil surveys for a total of 11 east central Michigan counties were digitized under this effort by the Michigan Department of Agriculture and Rural Development (MDARD). Additional work will be completed for other areas of the state as time and resources permit. 2011 status: Additional progress on this objective has been slowed due to lack of staff, competing work priorities, and political and fiscal realities. This objective is not feasible given current and projected future resource environments. It will be tabled for the foreseeable future. Refer to the "Compendium of Addressed Objectives" table. BC REVIEW: This is another case in which the size of the task would become substantially easier to manage as the extent and quality of statewide digital data sets continues to develop. At a point when topographic, hydrologic, and other data can be readily integrated using a Geographic Information System, the staff time and resources needed to accomplish this type of task (in tight budget times) should become affordable enough to provide confidence that the net benefits realized from the effort will be substantial enough to offset the costs of the project. ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: This item is directed primarily toward flood prevention (and may also be useful for the handling of droughts).
Objective 2.10: Promote the establishment of minimum setback requirements for agricultural drainage ditches.	• Develop and distribute guidance (through the Michigan Cooperative Extension Service and/or related organizations) on "best practices" for greenbelts along agricultural drainage ditches. • Study the feasibility of legislation requiring a state setback standard. • Study the feasibility of legislation allowing for acquisition of buffer strips, or easement rights through tax abatement or other financial mechanism. • Seek legislation for both (if feasible).	REMOVED	N/A	HMGP, EMPG, State Funding (General Fund)	May also want to consider developing a slogan emphasizing the need to keep the edges of drainage ditches "green" to prevent sedimentation and exacerbation of flood hazards? 2011 status: Additional progress on this objective has been slowed due to lack of staff, competing work priorities, and political and fiscal realities. This objective is not feasible given current and projected future resource environments. It will be tabled for the foreseeable future. Refer to the "Compendium of Addressed Objectives" table. BC REVIEW: Taking a regulatory approach to a statewide effort such as this helps to spread thin the costs of this type of change, so as to be less heavy for any particular agency or location, and thereby likely to result in net benefits overall. This is particularly true when the regulations tend primarily just to improve the quality of future decisions, rather than to require the correction of past mistakes. ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: This item is focused on flood prevention, which may also prevent various types of secondary impacts from flooding.
Objective 2.11: Develop and distribute detailed maps showing drains and their flow direction, to assist in disaster response actions associated with liquid pollutants.	• Digitize drainage channels of all Michigan counties to show drain routes, characteristics and flow direction. • Work with county road commissions to have drain routes and flow direction included on official county road maps. • Work with county planning departments and regional planning commissions to have drain routes and flow direction included on county land use and zoning maps.	REMOVED	N/A	HMGP, State Funding (General Fund)	Once fully digitized, drain routes should be included on county road maps and county land use / zoning maps to assist local responders during liquid pollutant emergencies involving drains. 2011 status: Additional progress on this objective has been slowed due to lack of staff, competing work priorities, and political and fiscal realities. This objective is not feasible given current and projected future resource environments. It will be tabled for the foreseeable future. Refer to the "Compendium of Addressed Objectives" table. BC REVIEW: Digital data has probably now advanced to the point where the staff and resource requirements for this objective are now much lighter (the use wall-to-wall aerial photo coverage and topographic information within a Geographic Information System) and therefore the task would become more clearly beneficial in terms of the realization of net benefits across the state. Although certain higher-risk areas might be focused upon, advances in digital technology may allow the entire state to be analyzed without too much additional cost. ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: This item is relevant to technological hazards involving hazardous materials, and may also relevant to human-related hazards involving public health emergencies, contamination, or deliberate sabotage/terrorism.
Objective 2.12: Develop and establish design, construction, and maintenance guidelines for dikes and levees protecting agricultural land.	• Develop and distribute (through the Michigan Cooperative Extension Service and/or related organizations) guidelines that incorporate current engineering and maintenance "best practices" for agricultural dikes and levees.	REMOVED	N/A	State Funding (General Fund)	2011 status: Additional progress on this objective has been slowed due to lack of staff, competing work priorities, and political and fiscal realities. This objective is not feasible given current and projected future resource environments. It will be tabled for the foreseeable future. Refer to the "Compendium of Addressed Objectives" table. BC REVIEW: The costs would primarily be the staff time involved in researching, producing, and promoting the adoption of these guidelines. Web-publication of such guidelines would be quite inexpensive, but likely to result in safety improvements in at least some of the state's many agricultural areas. ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: This item is focused upon flood control infrastructure, which involves both natural and technological components. Consideration will be given to the expansion of this item to include a reference to the protection of such critical infrastructure from sabotage/terrorism, which makes the topic also relevant for human-related hazards.

Compendium of Addressed Objectives

(The following objectives have either been completed or removed from further consideration due to non-feasibility, consolidation, or other reason.)

Objective (in 2008 MHMP)	Implementation Method	Completed or Removed?	Date Addressed	Funding Source	Comments / Rationale
Objective 2.13: Increase awareness of community officials about state codes and standards for water and sewer systems, and the permit processes for system alterations, to prevent frost damage to new and existing infrastructure.	• Issue MDEQ guidance to local communities on a regular basis, with special emphasis placed on ground freeze mitigation. • Include the guidance in the MSP/EMHSD Statewide Mitigation Marketing and Public Education Project under Federal Disaster 1346, which is targeted at seven professional groups that influence mitigation decisions at the local level. (Public works officials are one of the seven targeted groups.) • Fully integrate ground frost damage prevention measures into all system master plans and the permitting process for system improvements and alterations.	COMPLETED / CONSOLIDATED	N/A - ONGOING	HMGP, PDMP, State Funding (General Fund)	2011 status: Bullet 2 is being addressed by Objective 1.1 (mitigation marketing / education campaign for target groups). Bullets 1 and 3 are part of ongoing system monitoring and regulation efforts by the MDEQ to ensure the structural and operational integrity of water and sewer systems against natural, technological and human-caused hazards. This is an ongoing, established process that has been strengthened in emphasis since Michigan's infrastructure "freeze disaster" (Federal Disaster 1028-DR-MI in 1994) and is adequate to meet the State's needs in this area. For these reasons, this objective is being removed from further consideration and placed in the "Compendium of Addressed Objectives" table. BC REVIEW: This objective can be served by the distribution (or web-posting) of information, or by attendance/presentations at meetings and appropriate conferences, or by the submission of materials to newsletters, electronic networks, or targeted publications. All these options entail only low-to-moderate costs, and the selected approaches can be readily adjusted over time to suit the current staffing and budget situations of the implementing agency. Thus, the benefits of this effort are very likely to outweigh the costs involved. ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: This item relates directly to technological hazards involving infrastructure failure (even if the ultimate cause of that failure stems from weather hazards), and this infrastructure is also relevant for the human-related hazard of public health emergencies.
Objective 2.14: Develop water system master plans that adequately address ground freeze protection for those communities that don't presently have such plans.	• Work with the MDEQ to determine which communities in Michigan do not have water system master plans that adequately address ground freeze protection. • Determine the most appropriate method(s) for providing technical assistance to complete a master plan. • Study the feasibility of using HMGP and/or PDMP planning funds to provide technical assistance for completing master plans that feature freeze resistance as a plan component.	COMPLETED	N/A – ONGOING	HMGP, PDMP, State Funding (General Fund)	A water system master plan can help communities develop and implement both short and long-range preventive measures for ground frost damage. 2011 status: Bullets 1 and 2 are part of ongoing system monitoring and regulation efforts by the MDEQ to ensure the structural and operational integrity of water and sewer systems against natural, technological and human-caused hazards. This is an ongoing, established process that has been strengthened in emphasis since Michigan's infrastructure "freeze disaster" (Federal Disaster 1028-DR-MI in 1994) and is adequate to meet the State's needs in this area. Bullet 3 is not feasible because of fund work eligibility restrictions and because other funding sources exist for this type of assistance. For these reasons, this objective is being removed from further consideration and placed in the "Compendium of Addressed Objectives" table. BC REVIEW: Coordination would need to take place to determine which systems have need, and how such plans could most efficiently be developed. This would probably vary from jurisdiction to jurisdiction, and the focus might fall upon those jurisdictions that seem to have the most urgent need, thus allowing a reasonable certainty that the involved efforts will result in positive benefits. ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: This item relates directly to technological hazards involving infrastructure failure (even if the ultimate cause of that failure stems from weather hazards), and this infrastructure is also relevant for the human-related hazard of public health emergencies.
Objective 2.15: Establish formal "let run" policies and procedures to keep water moving through a community's system to prevent freezing during periods of extended or extreme cold weather.	• Issue MDEQ guidance to local communities on a regular basis, with special emphasis during extended periods of extreme cold temperatures. • Include the guidance in the MSP/EMHSD Statewide Mitigation Marketing and Public Education Project under Federal Disaster 1346, which is targeted at seven professional groups that influence mitigation decisions at the local level. (Public works officials are one of the seven targeted groups.) • Fully integrate let-run policies and procedures into all system master plans.	COMPLETED / CONSOLIDATED	N/A – ONGOING	State Funding (General Fund)	Community let-run actions are initiated and terminated locally, with little uniformity or consistency. Development of formal state guidelines would help ensure that let-runs do not adversely impact water and wastewater treatment operations and community fire suppression capabilities. 2011 status: Bullet 2 is being addressed by Objective 1.1 (mitigation marketing / education campaign for target groups). Bullets 1 and 3 are part of ongoing system monitoring and regulation efforts by the MDEQ to ensure the structural and operational integrity of water and sewer systems against natural, technological and human-caused hazards. This is an ongoing, established process that has been strengthened in emphasis since Michigan's infrastructure "freeze disaster" (Federal Disaster 1028-DR-MI in 1994) and is adequate to meet the State's needs in this area. For these reasons, this objective is being removed from further consideration and placed in the "Compendium of Addressed Objectives" table. BC REVIEW: Although some water is used with this practice (and thus causes an expense), the damages caused by frozen pipes can be disastrous, and so the expense of this preventive practice has been determined to be justifiable. The establishment of formal policies would probably not cause very great expense to any particular stakeholder (although such things could be explored during the actual process of establishing these policies and procedures). ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: This item relates directly to technological hazards involving infrastructure failure (even if the ultimate cause of that failure stems from weather hazards), and this infrastructure is also relevant for the human-related hazard of public health emergencies.
Objective 2.16: Determine if the State's cold weather engineering practices and standards are sufficient to mitigate water and sewer infrastructure freeze failure.	• Research and determine cold weather engineering "best practices" for water and sewer infrastructure (if different from current MDEQ practices and standards). • Determine additional costs of following the higher engineering standards and practices. • If the higher standards and practices are feasible, work with MDEQ to incorporate those standards and practices into current State codes, standards, and practices for design, construction, and alteration of public water and sewer systems.	COMPLETED	N/A – ONGOING	EMPG, HMGP, PDMP, State Funding (General Fund and State Revolving Funds for public water and sewer infrastructure improvements)	Could possibly be a planning/research project under the HMGP or PDMP? Could also possibly be done in house as a work project under the EMPG? 2011 status: Bullets 1, 2 and 3 are part of ongoing system monitoring and regulation efforts by the MDEQ to ensure the structural and operational integrity of water and sewer systems against natural, technological and human-caused hazards. This is an ongoing, established process that has been strengthened in emphasis since Michigan's infrastructure "freeze disaster" (Federal Disaster 1028-DR-MI in 1994) and is adequate to meet the State's needs in this area. For these reasons, this objective is being removed from further consideration and placed in the "Compendium of Addressed Objectives" table. BC REVIEW: Subject matter experts would need to obtain and study the current standards and practices to arrive at this determination. Even if this may seem at present to be a heavy staff burden for the most involved agencies, such a burden might be lessened by spreading the task out, at first, over a longer time and across many staff, and then later, after a certain amount of information has been collected, a more focused examination might be able to complete the task efficiently, without an excessive work burden at any particular time. ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: This item relates directly to technological hazards involving infrastructure failure (even if the ultimate cause of that failure stems from weather hazards), and this infrastructure is also relevant for the human-related hazard of public health emergencies.
Objective 2.17: Determine the feasibility of increasing the authority of the MDLEG Manufactured Housing and Land Development Division to allow for amendment or rejection of proposed manufactured housing subdivision plats that are located in, adjacent to, or would be adversely impacted by, technological hazard areas.	• Study the feasibility (and desirability) of increasing the MDLEG authority to amend or reject manufactured housing subdivision plats that are at risk (potential/actual) from technological hazard areas. • If feasible and desirable, develop a statewide standard and universal application of regulations in the development of manufactured housing subdivisions.	REMOVED	N/A	State Funding (General Fund)	At present, proposed manufactured housing subdivision plats are reviewed by the MDEQ for floodplain control, but no other agency reviews such proposals for other hazards, including technological hazards. Generally, subdivision development is a local zoning issue in Michigan. Local units of government have been reluctant to yield that authority to the State. A statewide standard and universal application of regulations in the development of manufactured housing subdivisions would be desirable, but may be heavily opposed by mobile home park developers and the Michigan Townships Association. However, the issue warrants further study. (Ongoing) 2011 status: This objective is not feasible given political and fiscal realities and current and projected future resource environments. It will be tabled for the foreseeable future. Refer to the "Compendium of Addressed Objectives" table. BC REVIEW: This objective is fairly modest in scope and therefore, in itself, should not entail a great deal of expense, compared with the scale of the issue it might eventually address. ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: This item is specifically aimed at technological hazards.

Compendium of Addressed Objectives

(The following objectives have either been completed or removed from further consideration due to non-feasibility, consolidation, or other reason.)

Objective (in 2008 MHMP)	Implementation Method	Completed or Removed?	Date Addressed	Funding Source	Comments / Rationale
Objective 2.18: Promote wind resistant construction techniques to builders and the public, to prevent / minimize major structural damage due to severe winds.	• Conduct a public information campaign aimed at increasing the use of structural fasteners in new construction and retrofitting of existing structures. The campaign could be part of an existing hazard awareness campaign (i.e., Severe Weather Awareness Week) or a separate effort. • Develop a slogan that promotes the use of structural fasteners in residential and commercial construction. • If the Michigan "Safety House" demonstration model project is implemented, wind resistant construction techniques will be highlighted in that demonstration model. (Refer to Objective 2.2 for details.)	COMPLETED	N/A – ONGOING	EMPG, HMGP, PDMP, State Funding (General Fund)	Possible slogan names: "Let's Keep it Together"; "Tie One On"; "Brace Yourself"; "Get a Grip"; "Don't Fall Apart"; "Remember the Lesson of the Three Little Pigs"; "Make the Connection"; "Let's Stay Connected"; "Strap it On to Keep it Together"; etc. 2011 status: This objective has effectively been met by regional and/or national advocacy and education campaigns conducted by fastener manufacturers, building supply retailers, nongovernmental organizations, and various governmental agencies – including FEMA. In fact, the FEMA web site contains excellent information on and provides links to other sites with information on wind resistant construction techniques through the use of structural fasteners and other means. Although a Michigan-specific campaign has not been established, these other efforts provide sufficient advocacy and guidance for builders and citizens wishing to increase structural integrity through the increased and consistent use of structural fasteners. Bullet 3 is not feasible because the objective related to development of the Michigan "Safety House" has been tabled from further consideration due to non-feasibility. Refer to the "Compendium of Addressed Objectives" table. BC REVIEW: This objective can be served by the distribution (or web-posting) of information, or by attendance/presentations at meetings and appropriate conferences, or by the submission of materials to newsletters, electronic networks, or targeted publications. All these options entail only low-to-moderate costs, and the selected approaches can be readily adjusted over time to suit the current staffing and budget situations of the implementing agency. Thus, the benefits of this effort are very likely to outweigh the costs involved. ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: This item focuses upon the severe wind hazard, but the protected structures can include critical facilities that relate to technological hazards such as infrastructure failure.
Objective 2.19: Develop a methodology for identifying and alerting communities of periods of extended or severe cold temperatures that could lead to widespread water and sewer system freeze-ups.	• Research the combinations of temperature, snow cover, soil conditions, pipe depth, water temperature (etc.) required to create water and sewer infrastructure freeze conditions. • Determine the number of days per year that infrastructure freeze conditions could be expected for each region of the state. • Establish a standardized warning classification system for the level of risk expected (i.e., freeze watch, freeze warning), similar to those used for severe weather. • Develop a warning notification system that can be utilized in all Michigan communities.	COMPLETED / REMOVED	N/A – ONGOING	HMGP, PDMP, EMPG, State Funding (General Fund)	Research efforts should involve the National Weather Service, Army Corps of Engineers Cold Regions Research and Engineering Laboratory, MDEQ, and the Winter Cities Association. Could possibly be a planning / research project under the HMGP or PDMP? Could also possibly be done in house as a work project under the EMPG? 2011 status: This objective is effectively met by ongoing system monitoring and regulation activities by the MDEQ to ensure the structural and operational integrity of water and sewer systems against natural, technological and human-caused hazards. This process has been strengthened in emphasis since Michigan's infrastructure "freeze disaster" (Federal Disaster 1028-DR-MI in 1994) and is adequate to meet the State's current needs in this area. Although a Michigan-specific classification system has not been developed, ongoing and ever-improving freeze forecasts by the National Weather Service provide sufficient early notification to community officials of the potential for infrastructure freeze-ups due to cold temperatures and/or ground frost depth. The feasibility of establishing, maintaining and consistently implementing a Michigan-specific early warning system is diminished by an ever-decreasing resource environment, and future resource allocations – if they are received – would likely be applied to other higher priority activities. For these reasons, this objective is being removed from further consideration and placed in the "Compendium of Addressed Objectives" table. BC REVIEW: The amount of work involved in setting up an additional protocol for weather-related notification shouldn't be very great, compared with the enormous costs that have been caused by freezing damage. ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: This item is most relevant for natural weather hazards, but also addresses the secondary impacts involving technological hazards such as infrastructure failures.
Objective 2.23: Mandate that schools, hospitals, fire stations, and other critical public facilities (paid for fully or partially by state funds) not be constructed in known hazard areas unless sufficient mitigation measures are implemented to reduce potential injuries, loss of life, property damage, and loss of function or essential services.	• Define what constitutes a "hazard area" and "sufficient mitigation measures" to ensure clarity and comprehensiveness in the application of the mitigation strategy. • Define what a "critical public facility" is and develop a statewide standard and universal application of regulations in the construction and siting of such facilities. • Ensure that provisions are put in place to eliminate any possibility of violations to the "Headlee Amendment" of the Michigan Constitution. • Study the feasibility of enacting legislation to ensure that this impact reduction measure is institutionalized in all program areas and for all types of applicable facilities. • Seek legislation (if feasible). • Develop new administrative rules as required.	REMOVED	N/A	State Funding (General Fund)	At present, there are no requirements for the location of emergency facilities, other than standard local zoning laws – many of which prevent building in floodplains. Local zoning laws rarely consider construction restrictions for other hazards. The Michigan Planning Enabling Act (2008 PA 33), passed after years of debate and deliberation by planning officials, elected officials and a number of other professional discipline stakeholders, does not contain this provision and a re-write of this law is highly unlikely given current and projected future political and fiscal realities. This issue is further complicated by the fact that there is no clear, universally accepted definition of what constitutes a "critical facility." Various federal emergency planning guidance documents provide brief definitions of critical facilities; however, there are widely varying opinions on these definitions. Critical facilities are also not clearly defined in Michigan law. 2011 status: Although this objective certainly has merit, its chance for implementation in the current and projected future political and social agenda is extremely low. Because there are other, higher priority mitigation needs and an ever-dwindling resource environment, it is unlikely that resources will be devoted to this objective in the foreseeable future. Therefore, it will be removed from further consideration and placed in the "Compendium of Addressed Objectives" table due to non-feasibility. BC REVIEW: This objective was intended to be able to have a preventive effect without entailing significant costs for its implementation, being primarily rooted in examining the procedures followed in capital facilities planning (primarily done at the local level), so that consideration must be given to the existence and location of identified floodplain areas or other known areas of higher-risk. The completion in recent years of dozens of hazard mitigation plans that cover the vast majority of Michigan's land area, from a local perspective, is a new resource that would allow this objective to be truly multi-hazard in scope, but at a minimum there could easily be a requirement that local Flood Insurance Rate Maps be consulted, which clearly identify areas of greater flood risk. The costs of looking at these available data sources are not great at all. This objective would lead to the consideration of more expensive activities that design or engineer such facilities into being hazard-resistant, but those costs would be seen as justifiable on a case-by-case basis, in view of the hazard vulnerabilities identified through this type of mandate. ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: This item refers to hazard areas, which are definable in terms of all types of hazards—natural, technological, and human-related.
Objective 2.24: Require colleges / universities to adhere to the provisions of the State Construction Code and third party inspections.	• Establish a dialogue with the MDLEG on the feasibility of including these structures in the Code provisions. • If feasible, assist the MDLEG in revising legislation and promulgating rules to include college facilities in the Code provisions.	COMPLETED	2002 / ONGOING	State Funding (General Fund)	2011 status: The enactment of the Construction of School Buildings Act (2002 PA 628) and the Stille-DeRossett-Hale Single State Construction Code Act (1999 PA 245) effectively addresses this objective. In addition, college and university facilities used for instructional purposes are also required to comply with the fire safety Administrative Rules promulgated by the State Fire Safety Board under the Michigan Fire Prevention Act, 1941 PA 207, as amended. Collectively, these regulatory mechanisms address the construction and occupant safety concerns at college / university facilities, as identified in this objective. Therefore, it will be removed from further consideration and placed in the "Compendium of Addressed Objectives" table. BC REVIEW: Colleges and universities typically have the capacity to realize this objective without undue hardship. The density of residential arrangements (and other functions) on academic campuses requires things to run smoothly, and also means that an emphasis on code compliance and inspections is not an unreasonable or inappropriate requirement. The costs of the types of accidents or injury that might result from non-compliance could easily be estimated to exceed the costs of non-compliance. Whether considered in terms of their housing, sporting/recreational, or employment/research functions, colleges and universities clearly have a lot at stake in maintaining efficient and safe operational arrangements for these activities, and each institution's reputation is also quite important to maintain. Therefore, there is already great cause for each institution to voluntarily wish to comply with or exceed code and inspection standards. Given what is at stake, benefit-cost considerations favor such compliance, and the promotion of such compliance to a mandated level should not be seen as imposing too much of an additional burden. ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: This item is relevant not only to the ability to withstand natural hazards, but also to prevent technological hazards. Connections may even be inferred between this item and the avoidance of human-related hazards such as public health emergencies.

Compendium of Addressed Objectives

(The following objectives have either been completed or removed from further consideration due to non-feasibility, consolidation, or other reason.)

Objective (in 2008 MHMP)	Implementation Method	Completed or Removed?	Date Addressed	Funding Source	Comments / Rationale
Objective 3.1: Integrate existing hazard awareness campaigns into one safety promotion campaign that addresses hazard vulnerability reduction, crime prevention, fire safety, traffic safety, school safety, etc.	• Study the feasibility of establishing a "Michigan Safety First Community" designation that local communities could work toward by undertaking appropriate public safety and hazard mitigation measures.	REMOVED	N/A	EMPG, HMGP, PDMP, State Funding (General Fund), Private Funding (Partners TBD)	The "Michigan Safety First Community" designation could possibly have a graduated incentives program (i.e., tax breaks, insurance rate reductions, less regulatory burden, etc.) as communities implement required actions in support of the designation. A detailed concept paper on the "Michigan Safety First Community" designation was developed by the MSP/EMHSD during FY 01. That paper contains implementation options for this initiative. 2011 status: The "Michigan Safety First Community" initiative (Objective 2.2) was tabled from further consideration due to non-feasibility; therefore, this tie-barred objective will also be tabled from further consideration. Given current and projected future resource environments, it is unlikely that either objective will be implemented in the manner described. Refer to the "Compendium of Addressed Objectives" table. BC REVIEW: Although it may take considerable time and coordination efforts to identify and organize the integration or coordination of these efforts, such coordination would be likely to result in certain efficiencies that would not otherwise have been realizable. More importantly, if such coordination also increases the level of awareness and effectiveness of even some of these safety campaigns, the resulting prevention of deaths, injuries, and property/service losses would reasonably be expected to justify these safety-promotion efforts. ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: This item refers to a full array of natural, technological, and human-related hazards.
Objective 3.4: Coordinate proposed recreation land purchases with identified flood mitigation needs across the state.	• Hold regular coordination meetings with the MDNR Parks and Recreation Division to review each agency's short and long term needs and proposed land purchases. • When possible, purchase land that has both recreation and flood mitigation value. • Develop strategies to integrate this objective into local planning efforts (e.g., hazard mitigation, comprehensive / land use, parks / recreation, etc.) to ensure it is considered in both long and short term land use / development decisions.	REMOVED	N/A	HMGP, EMPG, FMAP, PDMP, RFCP, SRLP Parks & Recreation Funding (federal, state, local)	Areas under consideration for purchase as open space or parks and recreation land may also serve the dual benefit of mitigating flood hazards by prohibiting residential or commercial development or providing space for storm water or seasonal runoff retention / detention. Conversely, areas under consideration for purchase for flood mitigation purposes may also have significant open space or recreation value. (Ongoing) 2011 status: Because of differing funding cycle time frames and purchase objectives, it is difficult to coordinate purchase activities with the MDEQ. In addition, virtually all land acquisition projects undertaken for flood mitigation purposes are done through local government-sponsored project applications. Many of Michigan's mitigation grant program funded flood acquisition and relocation projects have in fact purchased land that was then converted to permanent recreational open space. This purchase strategy is well-founded in local hazard mitigation plans and is strongly advocated by the MSP/EMHSD in its guidance and technical assistance provided to local mitigation plan developers and potential grant applicants. Current MSP/EMHSD and MDEQ staffing resources are inadequate to allow much time to be devoted to the proactive identification, statewide, of potential land purchases for flood mitigation purposes. In addition, the State of Michigan generally lacks matching funds to proactively purchase land itself for flood mitigation purposes – although the MDEQ occasionally purchases land for recreational purposes using dedicated (restricted) funding sources and in many cases the land purchased contains floodplain property. This objective is more appropriate for implementation at the local government level. The MSP/EMHSD consistently encourages the acquisition of flood prone property as a highly desirable and high priority hazard mitigation measure. Because this objective is better suited for local implementation, it will be removed from further consideration in this plan and placed in the "Compendium of Addressed Objectives" table. BC REVIEW: From the State government perspective, this action may end up entailing few additional costs, as procedures are developed and routinized, to make use of available flood information when engaged in recreational planning and related resource development and land acquisition/management decisions. From the local perspective, the costs of this activity (mainly in terms of time and staff efforts) can probably to a large extent be incorporated into the larger goal of integrating hazard mitigation practices into urban and regional planning activities. ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: This item is focused on the flood hazard, but may help to prevent secondary impacts involving public health and infrastructure failure.
Objective 3.5: Study the feasibility of requiring Michigan State Housing Development Authority (MSHDA)-financed structures to incorporate wind engineering techniques designed to reduce or eliminate future wind damage.	• Conduct a joint study (MSP/EMHSD and MSHDA) to determine if enhanced wind engineering measures would be feasible in MSHDA projects. The study should address both practical and financial considerations. • If the study results are affirmative, revise MSHDA documents and procedures as necessary to address the enhanced construction requirements.	COMPELTED	N/A – ONGOING	State Funding (General Fund)	It is good public policy to require government financed or government backed residential housing units to be built to a higher standard, making them more resistant to wind damage from tornadoes and severe winds. Government should lead by example. Generally, such measures are highly cost-effective and easy to implement if considered up front. 2011 status: A multi-county pilot wind engineering project was conducted with the MSHDA in 1999-2000 using $150,000 in U.S. Department of Housing and Urban Development (HUD) "Disaster Recovery Initiative" funding associated with the 1998 severe storms and flooding which struck the Midwest (and which resulted in Federal Disasters 1226-DR-MI and 1237-DR-MI in Michigan). Although this project was successful, the staff time required to coordinate, monitor and report activities was considerable and would be difficult to sustain on a regular basis. However, since that pilot project MSHDA has taken a more proactive role in promoting wind engineering in its projects. Wind engineering techniques are incorporated in MSHDA-financed structures when it is cost-acceptable to do so and/or when required by the State's *Single Construction Code*. The MSHDA has taken this proactive mitigation posture voluntarily. A formal mandate, requiring MSHDA to incorporate enhanced wind engineering techniques in all of its projects, is unlikely unless it comes directly from its counterpart federal funding agency, HUD. A state-level mandate is unlikely because it has the potential to increase costs for MSHDA building and rehabilitation projects (although only by a small amount) and the current political and fiscal environments are generally not amenable to increased, mandated regulations. Since the MSHDA voluntarily considers enhanced wind engineering in its structures, this objective will be removed from further consideration in this plan and placed in the "Compendium of Addressed Objectives" table. BC REVIEW: Initial costs of exploratory discussions would not be very large. A starting point might involve initial contact or meetings with MSHDA representatives, through which some of the information about wind engineering techniques would be relayed by hazard mitigation staff to selected MSHDA staff who would be able to evaluate the feasibility of incorporating such practices into MSHDA-financed structures. A focus might initially be placed upon particular areas of the state which have historically proven to be more vulnerable to high winds and tornado events, and the cost-effectiveness of wind engineering requirements might be tested in the highest-risk geographic areas of the state, as a basis for evaluating whether any farther-reaching policy change would be justifiable. ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: This item addresses weather hazards, but may also help to prevent secondary effects that may result from wind damages to residences.
Objective 4.5: Study the feasibility of developing a State Hazard Mitigation Fund to provide seed money to local communities and state agencies wishing to undertake mitigation initiatives.	• Study the feasibility of establishing a permanent fund for mitigation purposes. • Establish fund mechanisms and parameters in conjunction with the Michigan Department of Technology, Management and Budget (MDTMB). • Per Objective 4.6, develop protocols for soliciting and accepting donations from the private sector (businesses, philanthropic organizations, individuals, etc.). • As appropriate, seek funding from the Michigan Legislature. • Identify and seek funding from potential private sector donors.	REMOVED	N/A	State Funding (General Fund), Private Funding (Partners TBD)	2011 status: No additional progress has been made on this objective due to lack of staff and competing work priorities. Due to current and projected future political and fiscal environments, the likelihood of this objective being achieved is almost non-existent. The State's prolonged and severe economic crisis has effectively eliminated any possibility of a state-funded initiative of this nature, now or in the foreseeable future. For this reason, this objective will be removed from further consideration in this plan and placed in the "Compendium of Addressed Objectives" table. BC REVIEW: The feasibility of such a fund might be assessable under existing staffing and administrative arrangements within state government, given sufficient time, awareness, and cooperation among those who would need to be involved. The ultimate usefulness of such a hazard mitigation funding source would easily be expected to justify the efforts involved in bringing it about. ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: The general concept of hazard mitigation should be interpreted as including the consideration and alleviation of a full range of natural, technological, and human-related hazards.

Compendium of Addressed Objectives

(The following objectives have either been completed or removed from further consideration due to non-feasibility, consolidation, or other reason.)

Objective (in 2008 MHMP)	Implementation Method	Completed or Removed?	Date Addressed	Funding Source	Comments / Rationale
Objective 4.7: Develop a construction and maintenance manual for road and drainage construction and maintenance personnel (to minimize future flood damages).	• Review the hazard mitigation strategy document developed for 1128-DR-MI to determine the core issues identified by the interagency mitigation team. • Establish a subcommittee of subject matter experts to develop the manual. • Develop and distribute the manual. • Conduct training workshops on using the manual (targeting drain commissioners, road maintenance personnel, contractors, and farmers). • Consider integrating the manual into the CD produced under Objective 1.1 (statewide mitigation marketing and education campaign) since drain commissioners and road maintenance personnel are included in the target groups for that project.	COMPLETED	2010	HMGP, FMAP, PDMP, EMPG, State Funding (General Fund)	Recommended elements include (1) Construction standards and details for sizing, design of facilities, materials, installation methods for culverts, drainage ditches, and bridges, and (2) Maintenance techniques and scheduling methods (planning, funding, personnel issues, cost management, etc.). 2011 status: The excellent guidance documents produced by the MDEQ related to floodplain management ("Floodplain Management for Local Officials" and "Floodplain Management in Michigan: Quick Guide", as well as the "Flood Hazard Mitigation Handbook"), coupled with construction guidance documents developed by the MDOT for its staff, effectively meet the intent of this objective. Regarding Bullet 5, these documents will be referenced as guidance for public works personnel on the mitigation marketing and education campaign CD being developed under Objective 1.1. For this reason, this objective will be removed from further consideration in this plan and placed in the "Compendium of Addressed Objectives" table. BC REVIEW: A manual would primarily involve considerable personnel time for its development, but such costs can be accommodated, over time, within the normal staffing levels of state agencies. Distribution and publications costs can also be reduced through the use of modern electronic media such as the web-posting of the information. Compared to the enormous scale of Michigan's road and drain infrastructure (as well as the large number of local offices that handle these matters), the benefits of producing and distributing such information would pretty clearly outweigh the costs involved in its development. ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: This item focuses on the flood hazard, but is also relevant for selected additional hazards, such as infrastructure failures and transportation accidents, which are considered to be technological hazards.
Objective 4.8: Re-establish the low interest loan programs used in the mid-1980s to elevate and set back flood and erosion prone structures along the Great Lakes shoreline. Study the feasibility of establishing a similar program for riverine flood prone structures for elevation, flood proofing, or acquisition and relocation.	• Conduct a feasibility study of both options. • If feasible, present the concept to the Governor's staff for approval. • Seek a legislative sponsor for legislation to establish the program. • Provide follow up as needed through the legislative process.	REMOVED	N/A	State Funding (General Fund)	In the mid-1980s, zero interest loans made to erosion and flood-impacted homeowners as well as to flood-impacted agricultural producers. Under this program, the State took its invested funds out of investment and delivered those funds to local banks. The banks then loaned those funds at no interest to owners of flood- or erosion-impacted structures and flood-impacted agricultural producers. When the loan principal was paid back, without interest, the bank returned the money to the State. In this case, the interest the State normally would have earned on these funds, had they been invested, was lost. Due to the severe drought in Michigan during the summer of 2001, the agricultural community asked for a reinstatement of the zero interest loan program – a measure passed into law on February 27, 2002. However, legislators without a doubt would be reluctant to fund another zero interest loan program at the same time, especially when they recall that the true impetus of the mid-1980s program was double digit inflation, 20-percent unemployment rates, and 18-percent interest rates. The mid-1980s economic conditions were the driving force behind the program, and the flood disasters that occurred in 1985 and 1986 were merely the catalyzing agents that brought focus to the issue. 2011 status: No additional progress has been made on this objective due to lack of staff and competing work priorities. Due to current and projected future political and fiscal environments, the likelihood of this objective being achieved is almost non-existent. The State's prolonged and severe economic crisis has effectively eliminated any possibility of a state-funded initiative of this nature, now or in the foreseeable future. For this reason, this objective will be removed from further consideration in this plan and placed in the "Compendium of Addressed Objectives" table. BC REVIEW: The study of the feasibility of expanding this type of program to cover other circumstances would seem to be warranted in view of the numerous high-risk areas in which structures are also known to be at-risk from flooding and erosion. The loans themselves would involve individualized assessments of cost-effectiveness. ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: This item focuses on the shoreline erosion/flood hazard, although the function of some of the structures and infrastructure located within at-risk shoreline areas may allow this effort to also mitigation technological hazard impacts.
Objective 4.11: Study the feasibility of developing a state tax incentive program to encourage home and business owners to undertake mitigation measures that are consistent with local hazard mitigation plans.	• Research Michigan's solar energy tax credit program, as well as programs in place in other states, to determine the revenue and programmatic implications of implementing such a program. • If feasible, present the concept to the Governor's staff for approval. • Seek a legislative sponsor for legislation to establish the program. • Provide follow up as needed through the legislative process.	REMOVED	N/A	State Funding (General Fund)	Could be modeled after the state solar energy tax credit program instituted in the 1980s. Tax incentives send the strongest possible signal to the citizens of the state that hazard vulnerability reduction is important. The program could be used for both natural and technological hazard mitigation. 2011 status: Although this idea is certainly meritorious, given the current and projected future political and fiscal environments, it stands almost no chance of being implemented. The State's prolonged and severe economic crisis has effectively eliminated any possibility of a state-funded (i.e., via loss of tax revenue) initiative of this nature, now or in the foreseeable future. For this reason, this objective will be removed from further consideration in this plan and placed in the "Compendium of Addressed Objectives" table. BC REVIEW: Since hazard vulnerabilities end up costing the government a great deal of money in response and recovery costs, investments in hazard mitigation has been found to reduce such costs, in areas where projects are implemented. A tax-incentive program has the potential to be much more far-reaching, widespread, and efficient than traditional grant-based funding mechanisms, which are limited to specific selected projects that entail a great deal of labor-intensive preparation and administrative oversight. The amount of benefit, per cost expenditure, from a tax-incentive based mitigation subsidy could be enormous. ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: The general concept of hazard mitigation should be interpreted as including the consideration and alleviation of a full range of natural, technological, and human-related hazards.
Objective 4.13: Develop a Michigan-specific flood proofing handbook and make it available to home and business owners in flood prone areas.	• Establish a subcommittee of subject matter experts to develop the handbook. • Develop and distribute the handbook. • Conduct training workshops on using the handbook (targeting home and business owners).	COMPLETED	2010	HMGP, EMPG, FMAP, PDMP, CAP, State Funding (General Fund)	2011 status: The MDEQ publishes three excellent flood mitigation handbooks for local government officials, and these documents also have applicability to home and business owners. The titles of those documents are "Flood Hazard Mitigation Handbook," "Floodplain Management for Local Officials," and "Floodplain Management in Michigan: Quick Guide." These state-specific guidance documents, coupled with the excellent flood proofing guidance documents published by FEMA and available on the FEMA and Ready.Gov web sites, effectively address this objective. This objective will be removed from further consideration in this plan and placed in the "Compendium of Addressed Objectives" table. BC REVIEW: This objective required staff time and some other associated costs but was completed using existing governmental resources. The documents have been web posted by the MDEQ and are available online for statewide distribution. ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: This item focuses upon flood mitigation, but if flood proofed facilities include certain types of critical infrastructure, then such improvements may be considered relevant to the mitigation of technological and human-related hazards as well.
Objective 4.14: Study the feasibility of establishing a state-level insurance or low interest loan program to help repair, relocate, or fund mitigation measures for homes and businesses in subsidence prone areas or damaged by a subsidence incident.	• Study the state-level programs already in place in Illinois, Kentucky, Ohio, Pennsylvania and West Virginia to determine commonalties and parallels with Michigan's subsidence situation. • In conjunction with the MDEQ Geological and Land Management Division, prepare a position paper that outlines the scope and magnitude of the problem, probable costs associated with such a program, and alternatives that could be pursued to establish and implement such a program. • If feasible, present the findings to the Governor's staff for approval. • Seek a legislative sponsor for legislation to establish the program. • Provide for follow up as needed through the legislative process.	REMOVED	N/A	State Funding (General Fund)	2011 status: Although this idea is certainly meritorious, given the current and projected future political and fiscal environments, it stands almost no chance of being implemented. The State's prolonged and severe economic crisis has effectively eliminated any possibility of a state-funded initiative of this nature, now or in the foreseeable future. For this reason, this objective will be removed from further consideration in this plan and placed in the "Compendium of Addressed Objectives" table. (Note: Also see update comments for Objectives 4.5, 4.8 and 4.11.) BC REVIEW: The main costs of such a feasibility study would involve the time and resources used by personnel who have sufficient expertise—to design a research approach and then accumulate and evaluate appropriate information. Since there are few programs that are directly aimed at the mitigation of private risks from ground subsidence in Michigan, it is estimated that the administrative costs involved in a feasibility study may be offset by the benefits eventually derived from such a study, such as the identification of highest-risk areas in which more specific projects can be identified and implemented. If the proposed insurance or loan programs do not appear to be feasible, than the study would have prevented the application of funds to a lesser-addressed need, allowing available funds to be either applied or shifted to higher-priority concerns, in accordance with the findings of the study. ENVIR SOUND: Y, TECH FEASIBLE: Y, MULTI-HAZARD: This item focuses upon the subsidence hazard, but certain businesses and structures may include critical facilities whose safety and maintenance helps to alleviate technological and human-related hazards, as well.

Compendium of Addressed Objectives

(The following objectives have either been completed or removed from further consideration due to non-feasibility, consolidation, or other reason.)

Objective (in 2011 MHMP)	Implementation Method	Completed or Removed?	Date Addressed	Funding Source	Comments / Rationale
Objective 4.6: Evaluate flood damage to and caused by failure of sewage handling systems.	• Convene a subcommittee of subject matter experts from applicable agencies to review this issue in recent flood events and develop solutions to identified problems. • Implement the solutions where feasible.	REMOVED: Merged into Objective 2.7	2013	EMPG, CAP, State Funding (General Fund)	The 409 Plan for Federal Disaster 774, October 1986, recommended creating a multi-disciplinary task force to evaluate this issue. This issue has surfaced in more recent flood disasters as well. 2011 status: Little progress has been made on this objective due to lack of staff and competing work priorities. This objective is still valid and will remain active for future implementation. 2014 status: Little progress has been made on this objective due to lack of staff and competing work priorities. This objective is still valid and will remain active for future implementation, but has been into Objective 2.7, where it should be made a part of ongoing flood mitigation activities.

MITIGATION OPPORTUNITIES, RECOMMENDATIONS, AND IMPLEMENTATION

Summary of Target Completion Dates for Plan Objectives

Year	Objectives to Be Completed	General Priority Ranking
2015	**1.2: Encourage and promote multi-hazard emergency plans in all public and private institutions.** **2.6: Encourage Community Wildfire Protection Plans and establish and sustain additional FIREWISE communities, statewide.** **3.1: Promote urban forestry and vegetation management programs and initiatives to develop more resilient woodlands, streetscapes, and landscapes in communities throughout Michigan.** **3.2: Promote floodplain management activities throughout Michigan, increase statewide participation in the National Flood Insurance Program, and ensure that the NFIP policy base accurately reflects the flood hazard threat in Michigan.** **4.2: Promote better information flow on hazard mitigation among agencies, between levels of government, and between public and private entities.** **4.8: Highlight cost savings and other benefits to taxpayers due to mitigation measures that helped reduce future disaster damages.**	**HIGH**
2016	**1.1: Increase public / private sector awareness of hazard related dangers and mitigation solutions.** **1.6: Develop comprehensive hazard analyses / risk assessments (as part of a hazard mitigation plan development process) in all local emergency management program jurisdictions to address all pertinent natural, technological and human-related hazards.** **2.1: Increase knowledge of urban / regional planners and emergency managers about sound land use / development practices that can help reduce long term hazard risk and vulnerability.** **2.4: Acquire and relocate residential and commercial structures currently occupying floodways of Michigan rivers and streams.** **2.5: Acquire / relocate or elevate the worst repetitive loss structures in Michigan.** **2.7: Promote and assist with flood mitigation projects in all vulnerable areas, statewide.** **2.8: Promote and assist with wildfire mitigation projects statewide.** **2.9: Identify and fund appropriate mitigation measures for vulnerable public and private facilities and infrastructure.** **2.10: Promote and assist with severe wind mitigation projects statewide.** **2.11: Promote and assist with winter weather mitigation projects statewide.** **4.1: Educate and inform local and state officials, political leaders, the public, and involved professional disciplines about hazard mitigation concepts, programs, processes, and considerations.** **4.3: Continuously revise and enhance the Michigan Hazard Mitigation Plan (MHMP) to ensure it remains current, accurate, relevant, implementable, and in compliance with the federal Disaster Mitigation Act of 2000. (Update due in March 2017, but the hazard analysis is to be updated by 2015 or 2016.)** **4.7: Identify and formally recognize local, tribal, regional, state, or private projects and initiatives that have successfully incorporated hazard mitigation concepts and/or exemplify sound hazard vulnerability reduction strategies.**	**HIGH**
2017	**1.5: Support and utilize a system of real-time rainfall and river flow gauges throughout Michigan as part of an overall flood warning system.** **4.3: Continuously revise and enhance the Michigan Hazard Mitigation Plan (MHMP) to ensure it remains current, accurate, relevant, implementable, and in compliance with the federal Disaster Mitigation Act of 2000. (Update due in March 2014)** **4.4: Continuously monitor proposed legislation in Michigan for possible hazard mitigation opportunities and/or implications.**	**MEDIUM**

Summary of Target Completion Dates for Plan Objectives

Year	Objectives to Be Completed	General Priority Ranking
2018	1.3: Promote local early warning systems and capability.	MEDIUM
2019	1.4: Promote the concept of "safe rooms" within homes, businesses, and local / state governmental facilities to prevent / minimize injury and loss of life in tornadoes and severe winds. 2.2: Further define identified flood vulnerabilities in state owned / operated critical facilities. 4.5: Develop protocols for soliciting private sector donations for hazard mitigation purposes.	MEDIUM
2020		LOW
2021		LOW
2022	2.3: Identify critical floodplain storage areas within the state and enter the data into appropriate Geographic Information Systems to enhance future land use planning and development decision making.	LOW
2023		LOW
2024		LOW

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Michigan Hazard Mitigation Plan: Coordination with Local Hazard Mitigation Planning

State Support for Local Hazard Mitigation Plan Development

Provision of Technical / Direct Assistance

The MSP/EMHSD supports the development of local hazard mitigation plans through the provision of technical assistance (including on a request basis) and through the funding of local mitigation plan development under the Hazard Mitigation Assistance program, which includes the Hazard Mitigation Grant Program, Pre-Disaster Mitigation Program, and Flood Mitigation Assistance Program. The latter two components provide annual funding for plan development (although FMAP applies only to the flood portion of a plan), while the Hazard Mitigation Grant Program makes funds available after a federally-declared disaster. Most HMGP planning funds in Michigan stemmed from Federal Disaster 1346. (See the section below titled "Statewide Hazard Mitigation Planning Project.")

Historical overview since 2000

Technical assistance has included the provision of state-specific mitigation planning guidance (MSP/EMHSD Publication 207, "Local Hazard Mitigation Planning Workbook"), presentations, assistance with local meetings and group-input activities, assistance with locating data and planning resources, as well as direct "hands-on" assistance with the various steps of the planning process—up to and including the drafting, editing, and proofreading of final plans for adoption and approval. MSP/EMHSD first employed a dedicated local hazard mitigation planning specialist in the beginning of the year 2000, and shortly afterward, the Disaster Mitigation Act of 2000 began to mandate the development of local hazard mitigation plans as a pre-condition for the receipt of federal hazard mitigation grant funds (the requirement was not in effect until several years later). A second planner was often employed (subject to budgeting, hiring, and staffing constraints) as a hazard mitigation specialist during much of the following decade. Between 2000 and 2004, it was calculated that more than 200 meetings had taken place involving the MSP/EMHSD planning specialist(s), to provide direct assistance to communities and planners, and over 30 additional meetings also provided indirect support for these activities. State and federal guidance materials were produced and distributed, and over a dozen presentation and training sessions took place to teach hazard mitigation planning techniques.

That start-up phase of statewide hazard mitigation plan development led into the initial editing of the FEMA-approved Michigan Hazard Mitigation Plan in March 2005. The FEMA mandate for local hazard mitigation plans, as a condition of project grant eligibility, began to take effect. More than 45 Michigan meetings or sessions took place, involving the direct outreach on the part of MSP/EMHSD staff, during the period in which that initial MHMP was in effect. By 2008, the original MHMP had been successfully updated, federal guidance had stronger requirements for local hazard mitigation plan review, and the Flood Mitigation Assistance Program requirements were revised so that all communities were encouraged to produce all-hazard plans (rather than just flood-oriented plans).

By 2010, even before the initial set of local plans had been completed, the first of the required local plan updates began to come due under the five-year cycle mandated by the Disaster Mitigation Act of 2000. Far less state staff time could be devoted to local assistance, because of increased state planning activities, including Michigan's successful compliance with Emergency Management Accreditation Program requirements. Unfortunately, the same level of funding was simply not available at that time as there had been for the initial period of plan creation. Homeland security funds starting shrinking each year. In addition, as a result of economic problems and property value collapses, many community budgets found it much more difficult to arrange for the required local match portions of grants. This difficulty not only affected the ability to successfully apply for local plan development funds, but also the ability to support hazard mitigation project funds—one of the motivating "carrots" that was available to reward the successful completion of a local hazard mitigation plan. A couple of communities have succeeded in updating their plans on schedule, without the use of any additional planning grant funds, but with some help from MSP/EMHSD staff. MSP/EMHSD staff only has the ability to assist a limited number of communities at a time, and in the light of increased federal plan review requirements that have also been observed since 2008, Michigan seemed to be entering a phase in which a great number of its approved local hazard mitigation plans would expire due to insufficient funding, a dearth of local match resources, and limited staff resources available at MSP/EMHSD.

Nevertheless, a certain level of local assistance and outreach activities have been able to be maintained by MSP/EMHSD staff, on behalf of training and hazard mitigation planning activities. The following is a chronological list, since the previous edition of the MHMP was approved in March of 2011, of the meetings, presentations, and other outreach that MSP/EMHSD planning staff has provided in order to encourage and support the development of hazard mitigation plans throughout the State and to coordinate such plans with a broader comprehensive planning process. It does not include ordinary phone calls, faxes, and emails that have been used to promote and process local hazard mitigation planning activities during that time, even though some of these involved extensive data compilation, planning instruction, and document editing. (Nor does it include the numerous activities involving the MCCERCC, or on behalf of state-level planning, which are both described elsewhere in this plan.) The list instead only documents the actual face-to-face (or coordinated conference) arrangements that have been made by MSP/EMHSD staff on behalf of local emergency management programs and in the service of promoting hazard mitigation planning more widely throughout the state.

MSP/EMHSD staff outreach to promote hazard mitigation planning among local emergency management programs, local officials, other professionals, and the general public, from March 2011 to March 2014:

- April, 2011: Coordination and direct planning assistance with Kent-Ottawa regional plan
- April through September, 2011: Revision of Cass County plan (part of direct assistance)
- April 4, 2011: Conference call with Region 2 Planning Commission re: Jackson, Hillsdale, Lenawee plans
- April 21, 2011: RiskMap conference call
- May 20, 2011: Scheduling of "Discovery" meeting for RiskMap process
- June 2, 2011: Discovery conference call & kickoff of Clinton River watershed analysis process
- June 21, 2011: Collect plan info & send to RiskMap staff
- June 21, 2011: Collect plan info for Wayne County & send to RiskMap staff
- June 23, 2011: Coordinate with MSP district coordinators re: local outreach & direct planning assistance
- June 24, 2011: Discovery conference call to lend state support to the process
- July 7, 2011: Presentation on local planning & updates in District 7 coordinators meeting (in Gaylord)
- July 8, 2011: Presentation on local planning & updates in District 3 coordinators meeting (in Sandusky)
- July 13, 2011: RiskMap conference call & meeting
- July 21, 2011: Presentation on local planning & updates in District 1 coordinators meeting (in Mason)
- August 11, 2011: Presentation on local planning & updates in District 8 coordinators meeting (in Marquette)
- August 22, 2011: Presentation on local planning & updates in District 6 coordinators meeting (in West Olive)
- August 23, 2011: Presentation on local planning & updates in District 5 coordinators meeting (in Kalamazoo)
- September 13, 2011: Online survey for Oakland County plan (as stakeholder) and contact with their planning consultant
- September 15, 2011: Berrien County planning meeting in Benton Harbor (providing direct assistance)
- September 20, 2011: Oakland County planning meeting in Waterford Township (as stakeholder)
- September 27, 2011: Presentation on local planning & updates in District 2 coordinators meeting (in Oak Park)
- September 30, 2011: Conference call with planning consultant for Oakland (and Wayne) County plan updates
- October 12, 2011: Work with Region 7 planning office (Saginaw) on their scope of work description, on behalf of 5 multijurisdictional county plans (and provide feedback on October 28)
- October, 2011: New plan review guidance is released by FEMA
- October 26, 2011: FEMA webinar on new plan review guidance
- November 2, 2011: Participate in Region 14 planning office kickoff meeting for 5 county plan updates
- November 21, 2011: Complete online survey for Oakland County plan update (as a stakeholder)
- November 29, 2011: Participate in Oakland County planning meeting (as stakeholder)
- December 2, 2011: Conference call with University of Michigan-Flint planning consultants
- December 9, 2011: Kent-Ottawa plan submitted to FEMA (1st under new planning standards)
- December 20, 2011: Participate in Oakland County planning meeting (as stakeholder)
- December, 2011: Begin to provide direct assistance to the city of Ann Arbor for its local plan
- January 2, 2011: Draft of Ann Arbor plan posted on its website

- February 17, 2012: Meeting with consultants for the University of Michigan-Flint plan
- March 6, 2012: Conference call with Kalamazoo County (start of direct planning assistance to them)
- March 30, 2012: Kent-Ottawa plan meets FEMA review requirements (plan developed predominantly through direct assistance as the first under the new plan review guidance)
- April 17, 2012: Presentation given at Detroit planning meeting
- April 23, 2012: FEMA review finds that Lenawee County plan met requirements (direct assistance had been provided in the plan's completion)
- April 30, 2012: Investigation of Norton Mounds site preservation efforts on behalf of Kent County (to May)
- May 31, 2012: Presentation at Region 6 planning office's kickoff meeting on behalf of 3 county plan updates
- June 12, 2012: Presentation at District 2 coordinators meeting in Oak Park
- June 18, 2012: RiskMap conference call (FEMA, MDEQ, local meeting arrangements)
- June 20, 2012: Presentation on plan updates at Urban Area Security Initiative meeting in Macomb County
- June 26, 2012: Presentation at District 5 coordinators meeting in Kalamazoo
- July 11, 2012: Attendance at RiskMap workshop for Great Lakes analysis
- July 13, 2012: Presentation at District 3 coordinators meeting
- July 16, 2012: Meeting with Ann Arbor to support direct planning assistance
- July 18, 2012: Presentation at District 6 coordinators meeting
- July 30, 2012: Presentation at District 8 coordinators meeting
- August 2, 2012: Presentation at District 7 coordinators meeting
- October 4, 2012: Meeting with University of Michigan-Flint planning consultants
- October 10, 2012: Revise local "condensed" plan review sheets (for consistency with federal changes, while preserving some extra details about the requirements that were not included in the revised federal form)
- October 11, 2012: Conference call with Kalamazoo County re: direct planning assistance, and lay out the framework for direct planning assistance to update their county plan (in support of a FEMA-approved hazard mitigation project)
- October 22, 2012: Conference call with Kalamazoo County re: direct planning assistance
- November 7, 2012: Leading role in a Kalamazoo County plan update meeting
- November through December, 2012: Direct contact and outreach with local communities within Kalamazoo County, to assemble and discuss local planning sections for those communities within the multijurisdictional county plan
- December 5, 2012: Leading role in a Kalamazoo County plan update meeting
- January, 2013: Develop a framework for direct planning assistance to Ionia County, Mecosta County, Montcalm County, and Osceola County
- January 18, 2013: Register as Wayne County local plan stakeholder and answer survey questions for the plan
- January 23 and 29, 2013: Develop and revise new local coordination plan section in the MHMP to explain new prioritization criteria for direct planning assistance to local EM programs
- January 30, 2013: Participate in Wayne County local planning meeting in Romulus
- January through June, 2013: Begin work on updating EMHSD Pub. 207 "Local Hazard Mitigation Planning Workbook" – but this work is placed on hold due to other priorities and the release of new FEMA guidance on the subject (in March) that serves the same purpose; expected to resume in 2014-2015
- February 1, 2013: RiskMap meeting information sent to relevant local communities
- February 27, 2013: Participate in RiskMap conference call re: Osceola, Isabella, and Muskegon Counties
- March 4, 2013: New FEMA guidance received on local plan review standards
- March 15, 2013: Second survey for Wayne County local plan update (as stakeholder)
- March 27, 2013: Presentations given at "Resilience meetings" for RiskMap: Mt. Pleasant (Isabella County) and Muskegon (Muskegon County)
- April 4, 2013: Meeting with Region 7 (Saginaw) planning staff – instructional on behalf of 5 counties
- April 10, 2013: Conference call on RiskMap (with FEMA, MDEQ)
- May 6, 2013: Presentations at planning meetings in Roscommon and Gladwin Counties (in support of Region 7 local activities)
- May 9, 2013: Presentations at planning meeting in Iosco County (in support of Region 7 local activities)

- May 9, 2013: Presentations at planning meetings in Isabella and Clare Counties (in support of Region 7 local activities)
- May 17, 2013: Meeting with Region 7 (Saginaw) planning staff – instructional on behalf of 5 counties
- June 10, 2013: Meeting at Region 12 planning office (Escanaba) to support their development of 5 county plan updates
- June 11, 2013: Meeting at Region 13 planning office (Houghton) to support their development of 6 county plan updates
- June 12, 2013: Meeting at Region 11 planning office (Sault Ste. Marie) to support their development of 3 county plan updates
- July 2, 2013: RiskMap conference call re: Arenac and Monroe Counties (RiskMap involves STARR, which is an alliance of several consultants on behalf of FEMA)
- July 10, 2013: Arenac RiskMap meeting attended by MDEQ staff
- July 11, 2013: Monroe County RiskMap meeting includes discussion of direct planning assistance to the county, starting in 2014
- July 12, 2013: Meeting in Centreville (St. Joseph County) and presentation regarding hazard mitigation planning and direct planning assistance to them, starting in 2014
- July 17, 2013: Direct planning assistance to St. Joseph County in adapting Emergency Action Guideline (EAG) content into their hazard mitigation draft plan
- August 1, 2013: RiskMap "webex" conference call with online presentation: resilience "lessons learned"
- August 15, 2013: Meeting with Region 7 (Saginaw) planners – instruction to support 5 county plans
- September 16, 2013: Planning meeting in Livingston County (Howell) to support their upcoming plan update
- September 26, 2013: FEMA webinar on hazard mitigation planning (supported and announced to local EMCs statewide by the MSP/EMHSD)
- October 10, 2013: FEMA conference call re: selecting RiskMap communities
- December 6, 2013: Participation in Allegan County planning meeting (Salem Township)
- January 8, 2014: Respond to Allegan County online survey for local plan update (as stakeholder)

These forms of assistance are expected to continue throughout the three-year period (2014-2017) covered by this plan. However, field visits have tended to be much less frequent since the initial MHMP was completed in early 2005. This is because of state budget cutbacks, transportation cost increases, economic declines within the State, limited staffing, and the periodic need to prioritize State-level planning and response activities. Much recent direct assistance has shifted toward phone and email communications, although some of that assistance has been extensive. However, training activities still occur through the delivery of MSP/EMHSD training courses (the MSP/EMHSD's lead local mitigation planner regularly gives presentations on mitigation planning and hazard analysis), the provision of guidance materials (including internet-downloadable copies), and feedback provided from the ongoing local plan review activities.

Since early 2011, the following local plans (or plan updates) have been completed, quite a few of which have involved the direct assistance by EMHSD staff: Bay County, Cass County (direct assistance), Jackson County (direct assistance), Oakland County (stakeholder participant), Bloomfield Township, City of Ann Arbor (direct assistance), Lenawee County (direct assistance), Hillsdale County (direct assistance), Berrien County (direct assistance), Kent-Ottawa regional plan (direct assistance), Kalamazoo County (direct assistance), University of Michigan-Flint, Pokagon Band of Potawatomi, Eastern Michigan University, Wayne County (not including the City of Detroit), City of Lansing, Baraga County, Ontonagon County, Gogebic County, Iron County, Houghton County, Keweenaw County, Alpena County, Alcona County, Oscoda County, Otsego County, Midland County. In addition, work has begun on numerous other plans, for as EMHSD staff had to shift its planning resources back into the required state plan update, new THIRA/SPR requirements, and disaster response and recovery (Luce and Schoolcraft County wildfire, flood disaster 4121), a large number of planning grants were also put in place to allow dozens of counties to have their plans updated. As already noted, direct EMHSD planning assistance is scheduled to resume for counties that have not yet had any FEMA-approved plan completed in the past: Ionia County, Mecosta County, Monroe County, Montcalm County, Osceola County, and St. Joseph County (with Branch County also to be assisted as time and resources permit).

Cooperating Technical Partners Program (NFIP Floodplain Mapping and Map Modernization Program)
The Michigan Department of Environmental Quality, Land and Water Management Division (MDEQ/LWMD) also provides some technical assistance to local communities in developing floodplain maps through its "Cooperating Technical Partner" (CTP) Program. Under the CTP Program, states and local communities with demonstrated resources and expertise are delegated the authority to review and publish National Flood Insurance Program (NFIP) studies without the need for further federal review. The state and local communities, as CTPs, may also process revisions to existing NFIP studies and then re-map the floodplain. Local community resources may include, but are not limited to, gathering of field data, labor, funding, in-house information, and providing technical expertise to print the floodplain maps. The MDEQ/LWMD devotes staff time and technical expertise to develop hydraulic models and produce the NFIP reports and associated digital floodplain maps which are then made available on the MDEQ/LWMD and FEMA web sites. This information can help to inform communities as they proceed with floodplain management and hazard mitigation planning efforts. Please refer to the Riverine Flooding Section in the Hazard Analysis section of this plan, for more information about the current Map Modernization phase of these activities.

Tribal Hazard Mitigation Planning within Michigan
Federally-recognized Native American organizations have the option to either apply directly to FEMA for hazard mitigation planning funds and technical assistance, or to coordinate with the State of Michigan to apply for State-administered funds. In the former case, the Native American area would be treated as if it were a State, dealing directly with FEMA. In the latter case, the Native American area would follow the same procedure that Michigan's local governments do to obtain funds and produce plans. Since most of Michigan's townships, cities, and villages do not have their own separate emergency management programs, but instead have granted that function to a county-level emergency management office, most of these local units of government are covered under County-wide hazard mitigation plans (which are treated as multi-jurisdictional plans and reviewed differently to be certain that they adequately cover all participating communities). Some of Michigan's recognized Native American areas and organizations have participated in the hazard mitigation planning process of the county or counties in which they are located, and have then adopted that multi-jurisdictional plan so as to gain FEMA approval and grant-eligibility for hazard mitigation projects. One of the most interesting examples of this involved the Grand Traverse Band of Ottawa and Chippewa Indians, which participated in and adopted hazard mitigation plans for <u>five</u> counties in which their members reside, with the coordination of the Northwest Michigan Council of Governments. A few tribal organizations have developed their own separate hazard mitigation plans. More information follows.

MSP/EMHSD offers and provides technical assistance to recognized tribal organizations just as it does to any of the counties or cities with their own emergency management programs. MSP/EMHSD has coordinated with the FEMA Region V Tribal Liaison as needed, to assist Native American areas and organizations.

Disaster-Resistant Universities
MSP/EMHSD has also supported the development of plans for colleges and universities (and their participation in local or multi-jurisdictional plans for the communities in which they are located). Many educational institutions have special planning needs and an unusual geographic layout within or across multiple communities and districts, and find benefit in developing their own distinct plans for hazard mitigation and emergency management. MSP/EMHSD has referred various communities, agencies, and institutions to the resources provided by FEMA for its Disaster Resistant Universities initiative. A few universities now have approved hazard mitigation plans, distinct from those of the communities in which they are located. More information follows.

Statewide Hazard Mitigation Planning Project
Recognizing the need to support the process of developing local hazard mitigation plans, FEMA authorized states to use up to 7% of allocated HMGP funds for the development of state, local or tribal hazard mitigation plans. The MSP/EMHSD and MHMCC (now MCCERCC) took full advantage of that planning provision in December 2001 and allocated 7% of available HMGP funds under Federal Disaster 1346 ($2.3 million of the $33.2 million allocation total) to support the development of hazard mitigation plans in emergency management program jurisdictions in Michigan (all 83 counties plus selected municipalities over 10,000 in population). With the 25% local match factored in, the total funding available for mitigation plan development exceeded $3 million. Annual Pre-Disaster Mitigation Program funds (administered by the MSP/EMHSD) allowed the development of additional plans, primarily in the more densely-populated areas of southern Lower Michigan, starting in 2002. A number of additional plans had been subsidized through the Flood Mitigation Assistance Program for about 12 years starting in 1996, although many of those plans

covered only a single municipality rather than an entire county, as became standard with the other planning grants, and by 2008, the FMAP planning grants were allowed to be used only for the flood-portions of an all-hazard mitigation plan (the plan review standards for different programs were consolidated into a single set of all-hazard planning criteria and made a bit more strict than the standards used previously). Unfortunately, one community (Bloomfield Township) was "caught" by this policy change, and required direct MSP/EMHSD assistance in converting the scope of its plan from its original flood-focused study into a full multi-hazard mitigation plan.

This statewide planning initiative is still being implemented, since several communities ran into staffing and logistical problems that delayed their progress. Although the vast majority of Michigan counties were able to develop an approved local hazard mitigation plan using these funding sources, as of early 2014, there are still 7 counties that had not been able to do so completely. MSP/EMHSD has started to provide direct assistance to these counties, so that all parts of Michigan would finally have been covered by approved plans (even if some of these areas did not keep up with their plan updates within the FEMA-required 5-year time frame).

The map on the following page shows the state of this statewide planning goal as of late 2010. It does not show which plans have since expired. (A later map will illustrate the more recent status of these communities). Its main point is to illustrate how much of the state has successfully developed local hazard mitigation plans at some point during the past 12 years. Of the counties that have been marked as having plans "not yet FEMA-approved," several have since met this objective—the counties of Cass, Gratiot, Hillsdale, Jackson, and Lenawee are now covered by local hazard mitigation plans. (Other plans, however, have since expired—see the subsequent map for Dec. 2013.)

Note: Cass, Gratiot, Hillsdale, Jackson, and Lenawee County plans have been approved within the past 3 years.

Plan Development Process / Status

As shown in the preceding map, as of December 21, 2010, a dozen counties had not yet developed an approved plan. Three years later, five of these counties had achieved this goal. Of the seven counties that remain, three had not used federal funding under HMGP or PDMP (although Branch County had successfully applied, they later chose not to use the funds) MSP/EMHSD staff has started (or plans to provide) direct assistance to these seven counties, to allow approvable plans to be developed during the next couple of years. In the starting phase of this activity, draft hazard analyses have been under development for the four northernmost of the uncompleted counties (Osceola, Mecosta, Montcalm, and Ionia), and meetings have already taken place to arrange for similar assistance to Monroe and St. Joseph Counties. Similar assistance will be offered to Branch County, when staff time permits.

A variety of methods were used for the initial development of local hazard mitigation plans, depending on the local desires, capabilities and circumstances of each participating community. Many counties made use of the professional planning expertise and services of Michigan's Regional Planning Offices to assist with local plan development (although the resources available to these offices do vary, and not all of them work on this type of plan). In addition, many county and local planning offices were also heavily involved, as were local emergency managers and some colleges and universities. Michigan State University, Western Michigan University, and Central Michigan University have especially been instrumental in aiding the development of several county plans. Numerous local and state agencies, and local business and industry were also involved, where appropriate. The MSP/EMHSD has continued to provide direct planning assistance to those communities that require it, subject to staff and budget limitations. Each local mitigation plan has been (is being) developed using whatever methods were most appropriate for each community and have usually resulted in the development of plans within the required timeframes of the HMGP and PDMP grants. As listed previously, there have been numerous occasions when direct assistance has been provided by MSP/EMHSD staff in the development of local hazard mitigation plans. In addition to these external meetings, MSP/EMHSD staff was available on a daily basis through phone and electronic communications, and numerous questions, advice, draft reviews, etc. were handled through those means.

FEMA requires all states to submit plans to their Regional FEMA Office for official review. For Michigan, this refers to the FEMA Region V office in Chicago. Plans are reviewed by MSP/EMHSD planning staff using their own review form, which is consistent with FEMA's revised plan review tool (a previous edition had been called a "crosswalk") but contains more explanatory detail. MSP/EMHSD's role is designated primarily as an advisory one in this regard, as a means of supporting/completing local planning activities and assisting with federal review, for only the FEMA review of a plan is considered official (for FEMA purposes, making communities eligible to receive or directly benefit from hazard mitigation project funds). Plans received by the MSP/EMHSD were reviewed (unless special circumstances required submission to FEMA instead) and when review criteria were met, the plans were forwarded to FEMA with the recommendation that they be approved. Such submissions were accompanied by documentation that the plan, in the judgment of the reviewer, met the local planning requirements of the Disaster Mitigation Act of 2000. If one or more review items were deemed inadequate, a (state-reformatted) "condensed plan review form" was returned to the community to convey the elements in which the plan's quality or content needed enhancement. Comments or suggestions were included in reviews, describing corrections, additions or deletions that the reviewer believed to be necessary for official approval, plus any other recommendations the reviewer believed would help to improve the quality of the plan without undue burden to those involved in the process. The MSP/EMHSD staff thus worked with communities and coordinated with FEMA as needed until the plans met all the required elements and were officially approved by a federal review.

The 2010 map of previous planning accomplishments only provides a fraction of the information relevant to the local planning process, however, because communities are on a 5-year plan development cycle, and need to update their plans regularly after their initial plans had been completed. With respect to this process, a different map is presented on the next page, which shows that there have actually been a fair number of communities whose completed plans have expired. As will be described shortly, however, many of those (but not all) are currently making use of funds to update their plans and thus regain their eligibility to benefit from project grant funds. The approved plan analyzes local hazards, risks, and vulnerabilities, and lays out potential actions to mitigate these; then the community should apply for specific projects that support or accomplish the proposed actions in its plan. The need to keep local plans up-to-date is an extensive, ongoing activity at both the local and state level.

Local Hazard Mitigation Plan Status
12/31/2013

Counties on the map are coded to match the categories below
Selected communities within the counties are listed to the right of those categories which apply to them in the descriptions below.

Plan Status

- No reviewable draft plan recieved: Battle Creek
- Old plan has expired (an update process is needed)
  Lac Vieux Desert Tribe,
  Grand Traverse Band
- Planning process currently under way:
  Delta Twp, Detroit
- Plan not yet approved by FEMA
- Plan meets requirements but
  NEEDS LOCAL ADOPTION:
- Plan approved & adopted: Participants are grant-eligible:
  Ann Arbor, Bloomfield Twp, EMU, Lansing, Pokagon Band,
  U of M Flint
- Plan is due for update within the next 2 years: MTU

The map on the previous page shows that a great amount of work needs to be done on an ongoing basis in order to keep local hazard mitigation plans updated on the required 5-year schedule. A lessened amount of available federal funds over the past few years (i.e. HMGP) has required alternative means of plan update to be considered and utilized—especially for those communities for whom the use of grant money has not seemed feasible or politically desirable, and who have thus not yet completed an initial plan. The most promising technique to accomplish local plan updates through direct EMHSD assistance involves the following process:

1. Since the core of a good hazard mitigation plan is its hazard analysis section, available staff can consider all convenient sources of hazard information, while taking into account the strengths and weaknesses of alternative sources.
2. The most readily available information sources will be used to provide locally-specific information that can be incorporated into community hazard mitigation plans. The focus will be upon procedures that do not require special expertise (i.e. funded assistance) to complete.
3. MSP/EMHSD staff determines the amount of direct assistance that it can provide to local planning efforts.
4. MSP/EMHSD staff determines which communities are in greater need of assistance, and how to prioritize their assistance to multiple communities that may have simultaneous competing need for it.
5. MSP/EMHSD staff will then meet with local emergency managers as needed (e.g. by attending the MSP district coordinator meetings that occur regularly in multiple locations, or through the scheduling of more customized meetings), and will present the ideas for plan update and direct assistance procedures to the local emergency managers and MSP district coordinators.
6. Direct assistance with plan updates will then proceed, according to the priorities developed and discussed, to most efficiently serve the communities that were considered to have the most pressing needs for planning assistance.

Current priorities for direct planning assistance are tentatively proposed as follows. These ideas can be expected to be re-shaped and refined as discussions with local and district staff proceed throughout 2014.

1. Communities that have specific projects they have arranged to fund through the federal Hazard Mitigation Assistance program will be prioritized over those that do not have specific project ideas. (Rationale: HMA assistance requires a completed or updated local hazard mitigation plan to be in place and approved by FEMA. Communities with fewer immediate needs for federal mitigation funding would be expected not to suffer so much from any lapse that may occur in keeping their local plan up to date.)
2. Communities with an active local emergency manager, who has a means by which the required local input/review process can take place for a plan, will be prioritized over those who do not. (Rationale: MSP/EMHSD planning staff can provide only so much direct planning assistance, but not the full local coordination that is required to bring a local plan to completion and get it adopted by local authorities. Therefore, and it makes sense to favor the provision of assistance to communities who can supplement it with their own efforts, without which a plan cannot be successfully completed. MSP/EMHSD work **alone** cannot cause a local plan to be successfully completed or updated. The update process goes beyond the mere revision of a planning document—it also requires a local review and input process, to guide and use information from an updated local hazard analysis and put it to work in updating a set of local hazard mitigation strategies to be implemented as a result of the plan.)
3. Communities that have more pressing needs, based either their history of emergency and disaster events, or based on the extent of vulnerabilities revealed by their local hazard analyses, shall be prioritized. (Rationale: Areas that are more vulnerable to damage or loss of life have more potential gains to be realized from efforts invested into hazard mitigation activities.)
4. Communities that have fewer alternative means of completing their hazard mitigation plans shall be prioritized for direct planning assistance by MSP/EMHSD planning staff. (Rationale: Limited MSP/EMHSD staff time is best used to serve those programs that have more limited capacities of their own. For example, local programs that have new emergency managers, EM programs that are part-time only, EM programs that are swamped with competing needs, those that are located in a region that is not as well-served by county/regional/university planning resources, or programs whose attempts to procure planning grants did not succeed, could all be perceived as having a greater need for direct assistance.)

Coordination with Local Mitigation Planning

To the extent practicable at this time, this plan has been developed in coordination with local hazard mitigation planning efforts. For example, the Hazard Analysis section of this plan was informed by locally-derived risk/vulnerability assessment information, while it in turn provides a great deal of information that can be used by local communities in their own planning. In addition, many of the MHMP objectives (discussed in the previous sections) were developed and selected after a consideration of not only the state's resources, authorities, and programs, but also (1) the identified local vulnerabilities to natural, technological or human-related hazards, (2) local project applications that have been received and processed by MSP/EMHSD (successful applications are described in Attachment C), and (3) hazard mitigation proposals that have been included in local plans reviewed by MSP/EMHSD staff.

Integration of Local Plan Data

Since this document is a state-level plan, it focuses primarily on issues and concerns of a statewide or regional nature and most of its plan elements are necessarily broad in nature, scope and application. The State of Michigan acknowledges the "home rule" principle that hazard vulnerabilities involving local communities, local hazard areas, and local facilities primarily need to be addressed in local hazard mitigation plans—since it is the local level at which zoning and building permits and land use planning takes place, and the local level at which local information and resources regarding drains and roads and municipal elected officials takes place. As a state plan, the MHMP necessarily takes a more "global" approach than any of the local plans, by addressing hazards and vulnerabilities across the state, which usually involves a level of agency that focuses upon coordination, guidance, leadership, encouragement, funding, regulations, legislation, and state agency resources—although at the same time including a consideration of local needs, priorities, information, and coordination. For 2014, the MHMP objectives described in this plan now include expanded consideration of specific types of hazards prioritized in part by local vulnerabilities (beyond the flood emphasis that has often characterized this type of planning). It has also been described how staff from MSP/EMHSD has provided ongoing assistance to local emergency management programs in the development of their local plans, and it is hereby noted that the same personnel who have coordinated with the local communities have also been the MSP/EMHSD personnel most heavily involved in the update of this State plan.

The process of updating the MHMP included the consideration of all approved local mitigation plans and planning draft materials on file with the MSP/EMHSD State Support Unit. In the few cases where the amount of such materials on file had been considered insufficient, direct contact had been made to survey that county and determine which hazards it prioritizes as posing the most local risk. Consideration was especially given to the following types of information, for local jurisdictions:

- Information on vulnerable residential and commercial structures in the floodplains and other hazard areas, where this was substantial enough to suggest a need for state assistance or awareness.
- Historical events and their associated loss estimates.
- Land use trends and associated areas of concern where development may overlap with identified floodplains and other hazard areas.
- Specific mitigation projects coinciding directly with state goals and objectives, or that exhibit concerns serious enough to warrant consideration at the state or federal level.

Consideration has also been given in avoiding the description of local information that may be considered sensitive or confidential, especially in light of homeland security efforts to prevent terrorism and similar criminal activities. MSP/EMHSD staff will continue to collaborate with local planners and emergency managers to ensure that accurate and best-practice data and maps are included in updated local and state plans in the future, and that outdated or unduly sensitive information does not enter into the plan. MSP/EMHSD staff may, in the future, develop additional planning guidance or policy memoranda on this data incorporation process. In addition to the direct contacts between local communities and state-level agencies that address various types of hazards (i.e. MSP/EMHSD, MDEQ, MDNR, MDOT, etc.), the MCCERCC has been involved through regular meetings and monitoring of the state planning and update process, and thereby connects state mitigation activities with many other agencies. This updated 2014 MHMP has been discussed with and reviewed by MCCERCC members, and its finalized version (the FEMA review copy) went before the MCCERCC's hazard mitigation committee in February 2014 and the full MCCERCC to give its approval in March 2014. Thus, although the MCCERCC (which includes representatives of the local emergency

management programs and the public at-large) had already been involved in the drafting process and its member agencies have provided extensive feedback on the updated plan (and its constituent hazard analysis, updated and published in July 2012 before being further updated for the full 2014 plan). Although the MCCERCC acts as an advisory body, its review and approval of this updated plan (at the same time that FEMA's review takes place) enables a confident set of recommendations or endorsements of the quality of this update to be made to the Governor, to allow timely review and approval from that office. (Both review processes lead into the official adoption of the finalized plan, the last requirement for full FEMA approval of the update.)

Local Programs, Policies, and Capabilities

Local emergency management programs vary widely in their resources, expertise, and capabilities, but also in their risks and needs. State agencies have therefore provided various forms of assistance and guidance to these local programs throughout the years. Land use policies are distinctly local in their nature, and tend to be some of the most important when it comes to hazard mitigation activities. Local governments and programs vary widely in this aspect, as well. Some have dedicated planning departments, while many others hire external assistance to meet planning requirements on an as-needed basis. As described in the State profile section of this document, a local community may have a very small population, or a very large one, and in both cases, there can be a wide variation in the quality of services it has available, either on a per-person or a per land area basis. The amount of resources available to county agencies (such as road commissions and drain commissions) also varies throughout the state. Non-profit regional planning agencies exist in Michigan, and have the entire state divided into 14 regions for which these office collect and provide information, but again, while some offices have excellent staff and resources available to assist with hazard mitigation planning, others do not have any additional resources ready to provide. Although a great many resources exist within the general Metropolitan Detroit area, the complexity of that area goes beyond any one agency—the municipalities and counties that compose the area do not have the authority to speak (or resources to act) on behalf of the entire metropolitan area, and the Southeast Michigan Council of Governments (SEMCOG) planning office tends to act within limited spheres of coordination and technical assistance. Although certain kinds of funds are technically available for use in hazard mitigation activities, they require a substantial amount of work to obtain and make use of, making their use impractical for certain jurisdictions whose staff and budgets have already been shrinking. Preparedness and response capabilities often receive the most attention—especially since these phases of emergency management have a clearer relevance to most types of hazards, while hazard mitigation has mainly been defined in terms of flood hazards and, to a lesser extent, wildfires and severe winds.

It is useful to admit that, from the resource-strapped perspective of local jurisdictions, the preparedness and response phases of emergency management are rational ones to favor, for most types of threats and hazards. For more than 10 years, state guidance has sought to advise and identify appropriate hazard mitigation actions for all types of hazards, but the most relevant often involve activities that may technically be deemed preparedness activities (or prevention or protection or other recently proposed "phases"). All important hazards can be prepared for, but when it comes to their prevention or mitigation, actual authorities and capacities often involve the private decisions of individuals and firms, and the efforts of government (at any and all levels) to try to regulate or place requirements upon these individuals and firms, without exceeding their political authority to do so. A compelling need is required in order to make strong regulations politically feasible and justifiable, yet when it comes to Michigan's array of hazards and threats, it often requires informed study to produce a reasonable understanding of their risks, with which it becomes possible to justify various costs. And yet, a large number of citizens do place great value upon individual responsibility (for which public awareness and educational actions are deemed most appropriate for government to take, as a kind of advisory role rather than a compulsory one), while resisting the capacity of government to strongly regulate what people are allowed to do with their own property. The value of higher levels of government for assisting local communities in dealing with a disaster is widely recognized, but the right of government to impose preventive regulations and policies, even if well-intentioned and demonstrably effective, often is not—particularly when accompanied by many sets of bureaucratic procedures and conditions. In cases involving clearly defined natural risks in specific areas, such as floodplains, efforts and costs are easier to justify (even though many persons have difficulty understanding the probabilistic aspects of flood risks). However, a great amount of planning activity has been occurring (at all levels) for years, in order to examine other types of hazards which are less clearly defined in Michigan. (Natural hazards such as tsunamis, hurricanes, and earthquakes, which are huge priorities in other states, are not particularly relevant for Michigan's communities.) Many hazards are associated with offsetting benefits. For example, floodplain locations are often very scenic and desirable places to be, except when a flood actually occurs. Woodlands are also scenic and

desirable, except when devastated by wildfires. Many other hazards threaten all locations in Michigan, even if some are far more threatened than others. But the levels of expectation, preparedness, and resilience also vary from community to community. Snowstorms, for example, have greater magnitude in the northern parts of Michigan, but do less damage there than in southern parts of the state, according to official records. This is seemingly due to greater preparedness in the north. Would similar levels of preparedness be considered as cost-effective in the southern parts of the state? Perhaps not. This is a tricky thing to calculate, except at the local level. But hazard mitigation planning is technically not required to (supposed to?) consider the benefits of preparedness activities, even if those are far more cost-effective than any of the available "mitigation" ideas. Therefore, the hazard analysis component of a hazard mitigation plan may be far more useful for emergency management programs in general (which are in charge of preparedness and response activities) than it is for the "mitigation" options that are offered for most of Michigan's hazards.

Hazard mitigation's most well-proven Michigan track record seems to be in addressing flood risks, but part of this is surely due to the fairly narrow way that hazard mitigation has been defined—as distinct from "preparedness." Within this fairly narrow framework, most local programs understandable focus upon what they are actually authorized to seek under available hazard mitigation funding sources. As seen in Attachment C, these tend to involve flood mitigation projects and the installation of warning systems. These are useful activities, and even though warning may be considered to be a preparedness or response activity, it is important that it has been allowed to be recognized as hazard mitigation (in view of its protective effects upon human safety). By comparison, it is harder (but not impossible) to justify the expense of widespread storm shelters, harder to re-engineer houses and buildings to be more wind-resistant, harder to re-design infrastructure to be freeze and earthquake resistant, and technically ineligible to fund most maintenance and repair activities under available federal funds, even when those would be plainly useful for hazard mitigation purposes (as when dredging drainage channels and clearing them of debris).

When tasked with identifying and achieving hazard mitigation actions, then, local programs seem constrained to operate within certain pre-defined boundaries that may not be immediately evident when the language and guidance surrounding hazard mitigation treats it as a conceptually open topic—an all-hazards approach with the implicit assumption that where there is a risk, there must surely be a corresponding risk mitigation strategy. Such strategies simply may not be of a kind for which any follow-up funding is available, however. The goal of integrating hazard mitigation concepts into other types of planning is meant to provide a way around these narrow constraints. What cannot be directly accomplished through available federal funds might be something that other funding sources can accomplish, or that can be addressed by more evenly distributing the costs of a solution among the array of underlying design, planning, political, and regulatory factors, rather than having them all hinge upon a specific, corrective project, after vulnerabilities have already been revealed.

The down-side to the integrated planning approach is that there are a great many communities for whom comprehensive plans are merely an occasional federally mandated requirement, rather than something that is seen as a vital force in shaping their community. This perspective, although it may seem like a very limited one to planners, is not an unreasonable one—especially for small communities whose character barely changes from decade to decade. Urban planning originated in a period of rapid population growth and economic industrialization. Over time, it was more broadly conceived in terms that made regional, state, and national planning seem to be equally viable, but in the United States, there have always been limits upon what community plans are authorized to do, and in a context where a community's plan accurately reflects local opinions, it may rightly be designed in a way that does not accomplish much except to try to preserve those things that many persons in the community admire and desire—the things that attracted them to (or kept them in) that community or geographic area. The limits to the idea of integrating hazard mitigation into local plans, is that only a minority of local plans are covering communities whose people desire (and are comfortable with) a particularly active or imposing approach to this type of regulation. And even in those communities, things are usually not accomplished without some costs. Where these involve costs that become privatized, individually opted for, or very well-distributed among all taxpayers, then hazard mitigation objectives may indeed be served. But this is achievable only very slowly, probably as a result of the public education and awareness-building activities as much as anything else, and not something that receives immediate recognition and support, especially at greater taxpayer expense. Greater incorporation of hazard mitigation concepts, designs, and activities into insurance policies and rates should probably be encouraged, as a way to more quickly achieve protective results (or an adequate distribution of the costs of safety improvements) than most local plans can probably provide. It is not denied,

however, that there are quite a few communities throughout Michigan that have plans (and financial resources) which could well-serve the goals of hazard mitigation. But when the most concrete risk-reduction activities are those that involve the design of private structures, or an awareness and preparedness-building approach, then a hazard mitigation plan might not do any better than to point in those directions, without the means to connect those actions with designated hazard mitigation funds or to use those parts of its plan to comply with federal review requirements, which ultimately call for the identification of projects that do meet funding eligibility guidelines.

This is the set of dilemmas in which local hazard mitigation plans have now been operating in Michigan, over the past decade or so. At the same time, community comprehensive plans are reluctant to impose private costs upon individuals and firms (or to recommend major capital improvements that might be too burdensome upon local budgets) in order to serve the often-abstract estimates of risks versus benefits, sometimes with very uncertain distinctions between individual level risks and responsibilities and those of community and government agencies, and for this reason, most such plans do not greatly add to the capacity for hazard mitigation in its fullest sense. While anything that promotes public education and awareness on the subject of hazard risks and vulnerabilities is surely helpful, many of the things that could reduce risks from the full array of identified hazards do not fall within readily defined areas for which specific actors can (or are willing to, or are able to) take specific palliative actions. There have also been widespread misunderstandings about how the development of local hazard mitigation plans do or do not tie in with various government mandates. For example, it is often believed or claimed that the lack of a local hazard mitigation plan will make communities and their members ineligible for any disaster assistance from higher levels of government. Although this is simply untrue, it also seems certain that this mistaken belief is one of the things that has allowed many local hazard mitigation plans to be developed and updated during the past 10 years—that with the understanding that the main state/federal reward for completing a local plan is the ability to access grant money to allocated specifically and solely to carefully defined forms of hazard mitigation projects, the incentive of local communities to go through the increasingly rigorous process of developing these plans is likely to decline. In some instances, the effort to navigate these types of misunderstandings, as well as the rather involved regulatory standards for local hazard mitigation plans, has *decreased* the willingness of some planning agencies to get involved in the activities. Hazard mitigation planning, and the potential for project funds that comes from the successful completion of such a plan, must be realistically perceived as being worth the efforts that it requires, in order for local support of the activity to continue. For some communities, operating under limited resources, a benefit-cost calculation may result in a decision not to undertake this type of planning, the local share requirements of the grants may make local projects seem too difficult to fund even when a plan is in place, and the bureaucratic requirements involved in obtaining such grants may be a third obstacle that may feel too difficult to overcome. Local programs are to be greatly applauded for the degree that they have succeeded in developing and maintaining updated local plans over the past 10 years, in spite of these great (and often increasing) challenges. It is usually more clear-cut and compelling to focus on the more immediate and mandated tasks of responding to an event, and increasing one's preparedness to do so. Fortunately, the development of a hazard mitigation plan does in most cases help agencies and communities to understand their hazards and thereby prepare and respond better to their next emergencies. It is not clear in many cases whether the benefits of hazard mitigation projects, specifically, outweigh the preparedness and response benefits that are realized through the plans' analysis of local hazards, and therefore which aspect of a local hazard mitigation plan is considered more beneficial for a community.

Future Planning Efforts

Support of Local Planning Activities

Following the adoption of this updated Michigan Hazard Mitigation Plan, planning efforts at the local level will continue to be actively supported through MSP/EMHSD monitoring, direct and indirect technical/planning assistance, and through administration of relevant grant funds and provision of guidance materials and training. (At the same time, other state agencies' ongoing outreach efforts, related to the various hazards in this plan (e.g. MDNR re: forest fires, MDEQ re: flooding, etc.), will continue. State and local coordination of hazard mitigation planning efforts during future plan updates (at both levels of government) will be enhanced through the:

- Sharing of state, local, and regional information on hazard incidents
- Sharing information sources (e.g. printed guidance, online databases, etc.) between state and local planners

- Provision of training sessions by MSP/EMHSD (and other state agencies) to local emergency managers, planners, etc.
- State, district-level, and local meetings, hearings, training sessions, conferences, etc.
- The Michigan Citizen-Community Emergency Response Coordinating Council
- Ongoing assistance to and feedback from local emergency management programs (direct and indirect)
- Coordination with state agency emergency management coordinators and MSP district coordinators
- Coordination with planning and emergency management agencies (e.g. MEMA)
- Coordination with other agencies who also work with local communities (e.g. Michigan's regional planning offices, MSU extension centers located in each county throughout the state, U.S.G.S. and National Weather Service offices, Silver Jackets, etc.)
- Numerous other contacts and information sources that are present during the various meetings and business conducted by, or attended by, relevant MSP/EMHSD planning staff (e.g. Michigan Climate Coalition)

Although an updated edition of MSP/EMHSD Publication 207 "Local Hazard Mitigation Planning Workbook" had been planned for 2013, it had to be delayed because new FEMA guidance came out during that year, a state disaster declaration occurred, and work had to move ahead on the required 3-year MHMP plan update. The FEMA guidance materials were considered adequate to provide guidance to Michigan communities and planners for the next couple of years, and the completion date of the revised Pub. 207 is now targeted for 2015 (following, and informed by, a series of commitments by MSP/EMHSD staff during 2014-2015 to directly assist at least 6 counties in completing their initial local hazard mitigation plans). If the state plan update schedule can be expanded to a 5-year cycle instead of the current 3-year cycle, it will be very helpful to free up state resources and better allow them to assist local communities with their planning and hazard mitigation activities.

For guidance on various aspects of the local hazard mitigation planning process, local communities and agencies have frequently been referred to (or provided with) copies (printed or digital) of the books in FEMA's "How To Guides" series (http://www.fema.gov/plan/mitplanning/resources.shtm#1). For guidance on the requirements of local hazard mitigation plans and their review standards, communities and agencies have regularly been referred to (or provided with) FEMA's "Local Mitigation Plan Review Guide" book and their more recent publication, "Local Mitigation Planning Handbook" (http://www.fema.gov/media-library/assets/documents/23194?id=4859 and http://www.fema.gov/media-library/assets/documents/31598?id=7209). It is considered that these books provide guidance to local planners and emergency managers that is sufficiently comprehensive and timely for their use in developing local hazard mitigation plans, and thus it was acceptable for the state guidance document to be delayed. (The latter FEMA document came out in 2013 and thus contained the most up-to-date and authoritative guidance about plan review standards.)

As stewards of both state and local mitigation planning in Michigan, the MSP/EMHSD and the MCCERCC are in a unique position to foster and arrange for state/local coordination through these techniques, plus new and updated plans, materials, and/or policy memoranda, training, plan reviews, advisory functions to other agencies, coordination meetings, and joint problem identification.

Searchable Hazard History Tool

The MSP/EMHSD continues to work at collecting and providing relevant and useful information to local jurisdictions regarding their hazards. One such effort had entailed the development of a searchable "hazard history" list that allows incidents to be tracked by county, based on information from the Law Enforcement Information Network (LEIN). This information has been used to assist various local communities in describing previous occurrences of hazardous events within their jurisdictions. It was hoped that this tool could, after additional development and formatting, be able to systematically provide additional detail about local hazard impacts, risks, damages, etc. to supplement the state maps/overviews and National Climatic Data Center sources that have typically been used in local planning efforts since 2000. In some cases, it has been used for this purpose, but doing so requires an extensive dedicated search by EMHSD staff, and therefore is usually only available in cases when that staff is directly assisting with local hazard mitigation planning. Although this tool is still being worked upon, new innovations have been found during the past 3 years that have suggested a change in approach for the information processing that is involved. It does seem likely that a great amount of information is available through alternative sources, such as the NCDC Storm Events Database (online). A greater degree of coordination has developed between the MSP/EMHSD and the USGS, with the result

that a great amount of the flood-related information can probably more efficiently be provided through USGS online tools (as well as those of the National Weather Service) and thus no longer need to be processed from LEIN information sources. As more efficient means of obtaining, collecting, and processing hazard and risk information are discovered or created, MSP/EMHSD intends to make the best use of such efficiencies. This type of flexibility serves the interests of all involved parties. Although the hazard history tool is still theoretically in development, it will likely be used more for technological and human-related hazards, which are not already covered by alternative sources. It therefore provides a complementary information source, since it is still in a cumbersome form, which can be improved upon only with considerable staff time (which has not been available because of higher-priority competing activities in recent years). No single information source is flawless, however, so even for natural hazards that are covered elsewhere, the compiled LEIN information is likely to include additional details. For other types of hazards, the searchable LEIN-based hazard history tool will likely be very useful for hazards such as hazardous materials incidents, plane crashes, and homeland security events.

Direct Planning Assistance

The process and timeframe for reviewing local plans will be a continuation of current procedures. A great number of counties currently have planning grants to update their plans, and, as described earlier, direct assistance by MSP/EMHSD planning staff will be offered to seven communities that need to update their plans but have not been able to receive planning grant funds through HMA. As always, preliminary reviews of draft materials will be provided upon request and full advisory reviews will be provided upon receipt of a submitted plan. Occasional exceptions must be made when staff time is already committed to higher-priority activities, such as active disasters, updating the state hazard mitigation plan, or grant-related deadlines. In these cases, FEMA staff have been requested to review such plans directly. Plans that are judged as needing enhancement in order to meet federal planning requirements will result in the provision of guidance and advice to local jurisdictions and/or their consultants. In some cases, with the approval of involved stakeholders, MSP/EMHSD staff will provide suggested language, procedures, methods, guidance, editing and proofreading assistance to support the successful completion of local plans. When such plans are completed, they are forwarded to FEMA for official review. Completed FEMA reviews are promptly relayed to appropriate local stakeholders upon receipt, along with any advice deemed pertinent to the federal review.

Including these ongoing procedures, the following approximate timeframe for additional anticipated planning activities is as follows:

- March 2014 – Official adoption of the 2014 Michigan Hazard Mitigation Plan update.
- 2014 to 2017 – Ongoing assistance with local mitigation planning, plan review activities, and planning grant administration, to promote the successful completion of as many local hazard mitigation plans as possible (including all those that had received funding support), and with special emphasis upon providing direct assistance to the seven Michigan counties that have not yet completed any FEMA-approved local hazard mitigation plan.
- 2014 to 2017 – Continued direct and indirect assistance to, and administration of available planning grant funds for, local communities that need to update their approved hazard mitigation plans.
- 2014 to 2017 – Continued expansion of the LEIN-based hazard history, and the investigation and development of other resources such as those provided by USGS, National Weather Service, and other agencies, to assist with local and state hazard mitigation planning and plan update processes—especially where such other sources may prove to be less labor-intensive than the EMHSD compilation of LEIN information.
- 2013 to 2015 – MSP/EMHSD planning staff provide direct assistance to selected local communities in order to directly assist with local hazard mitigation plan completion and update, following a set of procedures developed during 2013.
- 2014 to 2015 – MSP/EMHSD will update the “Local Hazard Mitigation Planning Handbook” (EMHSD Pub. 207) to include new information and amendments that are informed by the most recent known authoritative sources and the most recent federal planning requirements.

- 2014 to 2017 – MSP/EMHSD planning staff will meet with, provide information to, and offer assistance to all local emergency management coordinators, through the regularly scheduled MSP district coordinator meetings. At these meetings, staff will present relevant and information, guidance, and resources for use in local plan development and update processes.

- 2014 to 2017 – Continuing coordination with state agencies through the MCCERCC, the state agency emergency management coordinators meetings, and other staff contacts.

- 2014 to 2017 – Expanded coordination with the USGS, National Weather Service, regional planning offices, Michigan Climate Coalition, Silver Jackets, Michigan's many public universities, and agencies such as the Michigan Association of Counties, Michigan Townships Association, and Michigan Municipal League, and the Michigan Association of Planning, to promote and facilitate hazard mitigation planning.

- 2014 to 2017 – Continuing provision of training through regularly-scheduled MSP/EMHSD training courses, direct training provided by MSP/EMHSD planning staff, and outreach and presentations (at conferences, meetings, and university settings).

- 2014 to 2017 – Coordination with, and linking of, local hazard mitigation plans with the Michigan Hazard Mitigation Plan. Coordination proceeds in two directions: (1) assistance and guidance provided to local planning efforts, as described above, and (2) the use of information from local hazard mitigation plans to inform the Michigan Hazard Mitigation Plan, improve its information base, find new ideas for mitigation needs and actions, prioritize project funding, etc., as described previously and in other sections, as well as informing future refinements to the methods for prioritizing communities, accounting for development pressures, etc. As shown in Attachment G (Condensed Review Sheets), a new element was added to the end of Michigan's local plan review form—this form is used by EMHSD staff to provide feedback on how well local plans or draft material complies with federal regulations, and although there is no requirement that local plans must consider aspects of the state plan, an optional item has been included in the review form so that the possibility of such consideration and coordination may be proposed and considered by local plan developers.

Plan Maintenance and Mitigation Monitoring

Plan Maintenance

The MSP/EMHSD and MCCERCC are jointly responsible for the continuous maintenance and revision of this plan, although the MCCERCC's role is strictly advisory in nature. The MCCERCC continually examines planning-related issues at its meetings (full council meetings and committee meetings) and makes recommendations to MSP/EMHSD staff to conduct research as necessary and make appropriate revisions to the plan based on the Council's suggestions. Within the MCCERCC, plan maintenance responsibilities rest primarily with the Hazard Mitigation Committee. The MCCERCC Hazard Mitigation Committee and MSP/EMHSD mitigation staff will meet periodically to review and evaluate parts of the plan. (MSP/EMHSD and other agencies that are referenced, either directly or indirectly, in the list of MHMP Objectives will monitor progress in achieving or reassessing those objectives—see the following section on Hazard Mitigation Monitoring activities.) If deemed necessary and appropriate by the Hazard Mitigation Committee, representatives from local government, involved state and federal agencies, and nongovernmental organizations that participated in the plan development and/or that are impacted by the plan may be invited to participate in this review process. The Hazard Mitigation Committee will analyze the overall success and progress in implementing the plan, as well as the appropriateness of the plan content. Criteria that will be used to evaluate the plan include but are not necessarily limited to:

- The relevance and appropriateness of the plan goals and objectives in relation to current conditions;
- The nature, scope and magnitude of hazard-related problems in the state and country;
- The type and amount of resources available to implement the plan;
- The current and projected capabilities of the assigned implementing agencies;
- Relevant deadlines, priorities, and other consideration of the scarcity of available resources;
- Plan implementation problems that have occurred or that may occur, such as technical, political, legal, social, or coordination issues; and
- The overall success of actions that have been implemented.

In order to more evenly distribute heavy work burdens throughout the available timeframe for this 900 page plan, the hazard analysis section had, in 2012, been separately updated and published with the coordination of multiple agencies and their subject matter experts. A similar procedure is planned for 2015, so that later coordination may focus upon the other sections of the Michigan Hazard Mitigation Plan. As part of the review process, the Hazard Mitigation Committee will review the implementation methods for each objective with the party responsible for implementation to determine which methods worked (will work) well. In addition, the Committee will examine any difficulties encountered, assess how well coordination efforts are proceeding, and determine which methods need to be revised or strengthened. The Hazard Mitigation Committee will compile its findings and create a list of recommended changes that need to be made to the plan content or implementation. Detailed information about hazards and events tend to be compiled continually by MCCERCC agencies. New partnerships, information sources, and analytic methods will continue to be used, maintained, and improved.

The State Planner, lead Hazard Mitigation Planner, and other staff within the State Support Unit of the MSP/EMHSD will use these recommendations to make the necessary changes to the plan. The MSP/EMHSD State Support Unit staff and members of the MCCERCC Hazard Mitigation Committee will present the revised plan to the MCCERCC for its review, approval and adoption. The revised plan will then be submitted to the 1) State Director of Emergency Management and Homeland Security, 2) Deputy State Director of Emergency Management and Homeland Security, and 3) Governor for review, approval, and official adoption and promulgation by the State of Michigan. The newly revised and adopted plan will be submitted to FEMA for approval under the federal Disaster Mitigation Act of 2000 plan revision process—currently on a three-year cycle. Once approved by FEMA, the drafted sections of the plan will (subject to sensitivity considerations) be replace by final versions on the MSP/EMHSD web site. The finalized 2011 plan had been available for public review and comment for the entire three years until its update process was completed, and it will be replaced with the finalized 2014 edition, when that is approved. Hardcopy editions of the plan may be produced at the discretion of the MSP/EMHSD and MCCERCC.

Post-Incident Plan Review

As appropriate, the plan will be reviewed after Michigan receives a major disaster or emergency declaration under the federal Stafford Act. One such state/federal disaster had taken place since the 2011 edition of this plan had been completed (disaster #4121), and the strategy developed for this disaster has been included in Attachment F. The MSP/EMHSD and MCCERCC will jointly determine if additional review is required, and the extent of the review, based on the situational circumstances at the time of the declaration. (Similar consideration is given to the Michigan Emergency Management Plan, which serves as the response plan for the state.) The incident-specific hazard mitigation strategy document developed jointly with FEMA may in this way become incorporated into appropriate elements of the plan structure. Changes to the plan goals or objectives, or the prioritization of and/or implementation methods for the objectives, will be made if there is a compelling need to make such changes in order to expedite implementation of needed incident-specific hazard mitigation measures. Objectives for the 2014 update have been changed, in part from a consideration (or reprioritization) of activities and events that have occurred within Michigan during the past three years. Any routine or non-urgent changes noted during the post-incident plan review are to be made during the next scheduled plan revision cycle, due to the considerable amount of time and work that it takes to revise the MHMP.

For non-federally declared incidents involving natural, technological or human-caused hazards which cause a need for SEOC activation and/or significant state department involvement, the MSP/EMHSD will, at its discretion based on incident circumstances, review the plan for possible mitigation opportunities during the incident recovery period. In those instances, the MCCERCC may be consulted for its advice, expertise and resources as determined necessary and appropriate by the MSP/EMHSD. Mitigation opportunities will be pursued, at the discretion of the MSP/EMHSD and/or another state, local or federal department/agency with regulatory or stewardship authority over the hazard, if deemed appropriate and potentially effective for mitigating future such incidents and/or their associated negative impacts and consequences. Such mitigation actions may be reported on in the Incident Action Plan (IAP), Incident After-Action Report (if one is developed) and/or in standard Incident Status Reports. In some cases (at the discretion of the MSP/EMHSD and/or other regulatory/steward department or agency), a mitigation-specific report or strategy document may be developed to outline the problems encountered, the need for mitigation actions, and the specific actions taken and by whom. If such a report is developed, it may (at the discretion of the MSP/EMHSD) be appended to this plan for monitoring, implementation and historical record purposes. Again, routine or non-urgent matters are best handled through MHMP amendments that occur during the ordinary three-year update cycle, since this provides the greatest opportunity for coordination and feedback involving many agencies as well as the general public.

At a minimum, the post-incident review for possible mitigation opportunities could be recorded in the following table, to provide an historical record for the reviews that occurred:

Post-Incident Hazard Mitigation Plan Reviews, by Incident

Incident Date	Incident Type	Brief Description of Incident	Review Conducted By (Agency)	Specific Mitigation Actions Implemented	Implementing Agency

Hazard Mitigation Plan Monitoring

The responsibility for monitoring and tracking the progress of mitigation actions and project closeouts rests primarily with the MSP/EMHSD staff for activities that involve HMA funding, while other Objectives involve the activities of agencies such as the MDNR and MDEQ, who would thus handle the monitoring for these activities and report either through direct contact with MSP and other relevant agencies, or through their MCCERCC representatives. The MSP/EMHSD mitigation staff has always carried significant project monitoring and tracking responsibilities as the grant managers for the Hazard Mitigation Assistance (HMA) program (including HMGP, FMAP, and PDMP), which are often used to fund projects or actions listed in this plan (or which this plan supports for implementation by local communities in conjunction with their own plans).

MCCERCC's Michigan Community Emergency Response and Citizen Corps Coordination Plan

A significant component of the MCCERCC monitoring process involves the update of the mitigation elements in its own "Michigan Community Emergency Response and Citizen Corps Coordination Plan." This report is updated annually and serves as the "official" record of the MCCERCC-related mitigation achievements for each year. The MCCERCC's Michigan Community Emergency Response and Citizen Corps Coordination Plan and its updates are made available to the Governor and state agencies, the Michigan Legislature, and the state's local emergency management / homeland security programs. They have also been made available on the associated MSP/EMHSD and MCCERCC web site for viewing and downloading by the general public and other interested parties, at http://www.michigan.gov/msp/0,4643,7-123-60152_62790-198426--,00.html. Once projects or objectives are completed and closed out, they will be removed from the "active" objectives table of the MHMP by the MSP/EMHSD and reported on, as appropriate, in the MCCERCC's Michigan Community Emergency Response and Citizen Corps Coordination Plan—most likely in the form of a mitigation "success story." The project or objective will also be listed in the "Compendium of Addressed Objectives" table in the MHMP and the "active" objectives table will be updated accordingly. Many projects, however, are ongoing rather than fully completed, and in these cases, the MHMP reports the current status (in this case, any progress achieved since the previous plan update in 2011).

As indicated above in the "Plan Maintenance" section, the MCCERCC Hazard Mitigation Committee and MSP/EMHSD mitigation staff do meet regularly to review various sections of the plan (and its hazard analysis) during the three years between update deadlines for the MHMP's FEMA-mandated cycle. Part of that review and evaluation process includes a thorough review of the plan goals, objectives, and specific implementation strategies. The MSP/EMHSD charts progress on each objective, reports this to the MCCERCC Hazard Mitigation Committee in the MCCERCC Annual Report of Activities and during explicit MHMP update activities, and the results are summarized in the MHMP Objectives descriptions. This allow for regular review of progress and an easier update method that fits into the required three-year plan revision cycle. The MSP/EMHSD State Hazard Mitigation Officer (SHMO) will be primarily responsible for continuously tracking and monitoring the progress of implementation of the various projects and actions listed under each plan objective. As part of the annual report development, the SHMO will follow up with the involved parties throughout the year to determine the implementation progress and status. As appropriate, the SHMO will request periodic reports (verbal and/or written) on project status, conduct site visits, monitor media reports, hold conference calls or meetings, or use other methods as necessary to obtain status information.

Project Tracking, Monitoring, and Closeout

Mitigation projects listed in the MHMP that are being funded under the HMA (HMGP, FMAP, PDMP) are tracked, monitored and closed out by MSP/EMHSD mitigation staff in accordance with applicable federal and state laws and guidelines and the provisions set forth in the FEMA-approved State Administrative Plan and/or program guidance documents for each funding program. The status of each of these projects will be reported on periodically by the SHMO at MCCERCC Hazard Mitigation Committee meetings. Progress is also reported on quarterly reports to FEMA as per federal program requirements. All projects are closed out in accordance with the requirements set forth at the time of close out by FEMA. In general, the closeout process for grant projects under these programs involves reconciling the financial documentation, processing the final payment, conducting a site visit, photographing the project site, geo-locating the project, completing all required closeout paperwork (including environmental documentation), and submitting a closeout request package to FEMA. These activities are the responsibility of the SHMO and are sometimes carried out with the assistance of the Assistant SHMO or a FEMA Disaster Assistance Employee (DAE).

Monitoring Acquired Land

Another component of the grant program project closeouts involves the long-term monitoring of acquired lands. For newer project grants, the State is required to provide a report to the FEMA Regional Administrator every three years certifying that acquired lands continue to be maintained consistent open-space grant provisions. Michigan intends to report for all mitigation grant acquired lands rather than just for the newer projects, when requested to report by FEMA. To achieve this obligation, the assistance of MSP/EMHSD Regional Support Field staff will be employed. For emergency management and homeland security purposes, Michigan is divided into eight (8) districts with a MSP/EMHSD District Coordinator assigned to each. The District Coordinators work closely with the communities and local emergency management programs within their respective districts and therefore travel through their districts on a regular basis. Every three years, the SHMO will provide each District Coordinator with a list of properties, from the MSP/EMHSD GIS data base, that have been acquired with mitigation grants. Each District Coordinator will be

asked to visit the properties that are located in their district to confirm that the properties are being maintained appropriately. The District Coordinators will then report back to the SHMO who will compile an annual report of acquired property status. At MSP/EMHSD discretion, this report will be included in the MCCERCC's Michigan Community Emergency Response and Citizen Corps Coordination Plan. The report will be provided to the FEMA Regional Administrator upon his/her request every three years.

The MSP/EMHSD maintains a comprehensive data base of all HMA (HMGP, FMAP, PDMP) projects funded in Michigan, which it uses to track and monitor the projects and which also serves as a historical record of all projects funded under each program. A summary of those data bases (in table format) can be found in Attachment C in this plan.

Implementation Status of Hazard Mitigation Objectives: 2011-2014

Some of the mitigation objectives under each goal from the March 2011 edition of this plan have been implemented, some have not, and many are still in process. (Information related to implementation status for each objective is generally contained in the "Comments" column of each goal table in the "Mitigation Opportunities, Recommendations, and Implementation" section. In addition, the tables titled "Compendium of Addressed Objectives" contain a complete listing of those objectives that have either been completed or removed from further consideration due to non-feasibility, consolidation, or other reason.) The State of Michigan will continue to work towards successful implementation of the updated objectives during the next three-year revision cycle for this plan as time, resources, priorities, and circumstances permit.

A number of factors influenced the implementation of state-level mitigation objectives in Michigan during the period from 2011-2014, following upon a series of negatively impacting factors from the previous three-year period that limited or hindered full implementation of all scheduled objectives. The identified factors include:

- Lack of available state and local funds for project cost-sharing and general project implementation due to extreme state and local budget shortfalls. (Note: Nationally, in recent years, Michigan has either been dead-last or near the bottom in many state-level economic vitality indicators, and was also the only state to lose population between the 2000 and 2010 censuses.)
- Competing projects within the MSP/EMHSD and other agencies which addresses hazard mitigation activities, whether from disasters or other required emergency management activities, staff departures and reassignments, cross-training needs to prepare for the possibility of such departures or reassignments, etc.
- A huge decrease in homeland security funding for MSP/EMHSD and other agencies, causing additional work to find compensating or substitute sources of funding, or to calculate cheaper and more efficient means of accomplishing planned tasks with reduced funds and staff. In addition, an ever-increasing complexity of program requirements and correspondingly shorter timeframes for successful development and completion of activities under the various grants or mandates (e.g. THIRA) have created tremendous challenges.
- The general complexity and time-consuming nature of the DMA 2000 state mitigation planning requirements themselves, which siphon away scarce staff resources from efforts to implement the plan objectives.
- The statewide local hazard mitigation planning effort, which is in many ways a more natural level of government to be able to address hazards and implement specific projects in the field (or through land use regulatory functions, which are primarily held by local levels of government). Proposed legislation, to better coordinate state and local planning by increasing the state's plan update cycle from 3 years to 5 years, is supported by EMHSD staff, who recommend that this change be made as soon as possible.

Please refer to the "Mitigation Opportunities, Recommendations, and Implementation" section for a comprehensive discussion of the plan's goals, objectives, recent implementation status, and implementation methods. The various lists and tables provide background information on each objective, its priority and target timeframe for implementation, funding sources that might be used in implementation, and general comments regarding the status of implementation and possible implementation impediments.

Applicant Assurances

The State of Michigan will comply with all applicable Federal statutes and regulations during the periods for which it receives grant funding, in compliance with 44 CFR 13.11(c) and will amend its plan whenever necessary to reflect changes in State or Federal laws and statutes as required in 44 CFR 13.11(d).

At the time of application for FEMA mitigation grant funds, applicants sign FEMA Form 20-16 certifying that they will comply with applicable standard assurances as follows: (FEMA Form 20-16A) Assurances for Non-Construction Programs, (FEMA Form 20-16B) Assurances for Construction Programs, (FEMA Form 20-16C) Certifications Regarding Lobbying; Debarment, Suspension, and other Responsibility Matters; and Drug-Free Workplace Requirements, and (FEMA SF-LLL) Disclosure of Lobbying Activities. **At the time of grant award** for FEMA mitigation grant funds, recipients sign a grant agreement officially certifying that they will administer the grant in accordance with Federal regulations including (but not limited to) Titles 2, 31, and 44 of the Code of Federal Regulations, OMB Circulars, and applicable State laws and statutes.

General Loss Estimation for Natural Hazards

GENERAL METHODOLOGY

For this 2014 update, the general loss estimation tables for Michigan counties for flooding, tornadoes, thunderstorm hazards, winter storms, subsidence, coastal erosion, and earthquakes were predominantly developed using data from the National Climatic Data Center. The fact that NCDC is based on actual damaging events rather than theoretical estimates was a primary reason to shift to using this source, as well as its relative ease of use and authoritative source. Previous MHMP editions had attempted to begin with census data describing all households, and then estimate average damage amounts from derived area/frequency information across Michigan. This was considered to be a less valid method than making use of nearly 20 years of event data, now available in NCDC for many natural hazards. Updated census data regarding each county's population was used, however, to provide an additional reminder that life safety is a primary concern, even though this Attachment is meant to meet one of the planning requirements by estimating losses, in terms of quantitative damages. Information on life safety information can be found in the NCDC-derived summary tables in the hazard analysis sections of this plan. The newest census information from 2010 was used, along with NCDC searches from early 2014, which provided data on events as recent as October, 2013.

The primary data source for hazard occurrences and hazard related damages was the National Climatic Data Center (NCDC) Storm Data for Michigan. The NCDC Storm Data provided frequency and damage data for the following hazards: tornadoes, several kinds of strong and severe winds (which were combined together for this analysis), hail, lightning, snowstorms, ice/sleet storms, flooding, and wildfires. Although the type of information included in this data source has changed over the years (and tends to now include a lot of routine, non-emergency situations such as precipitation), this change seems to have resulted in a more consistent and thorough tally of annual events. These data were totaled for each county, similar hazards were summed together, and the total number of events was divided by the total time period to provide estimates of the historical probability of each hazard event per year, as well as the average/expected levels of damage from each hazard per year. These recent historical statistics were considered to be an appropriate means of estimating the future probability of hazard occurrences, however, this Attachment provides an extra type of analysis beyond that presented in the main hazard analysis sections, as will shortly be explained. For flooding, instead of focusing upon the reported number of flood prone residential units in each county as per the National Flood Insurance Program (NFIP) Community Information System (CIS) database, instead used the same procedure as the other hazards, for the current 2014 update.

A new feature in this update is the use of "smoothed data" for all of the above listed hazards except for flooding. All these natural hazards, except for flooding due to its tendency to predominantly affect low-lying areas of floodplains and specific weak-spots in urban drainage systems, have a wide-ranging potential area of impact. The fact that the historical data, although fairly extensive, dates back no more than 20 years from this source, meant that for less frequent hazards, such as tornadoes, an incorrect impression of the actual risks of damage might be obtained by using only the raw data alone. After all, if one tornado strikes a particular area of the state only once every 20 years in a damaging fashion, the fact that it had most recently occurred in one specific county does not mean that the risks for adjacent counties should be considered negligible. Rather, a means was need to allow the actual impacts to also reflect upon the general area where they could just as easily have struck, rather than just the specific area that they happened by chance to affect most recently. The procedure for adjusting the data, or "smoothing" it across adjacent counties, was to first use the original data as already presented in the tables throughout the hazard analysis sections of this plan, and to replace each county's information with an average of the statistics for itself plus all of its contiguous counties. This was accomplished through the use of Geographic Information Systems, and mapped output has also been provided in this Attachment, for easy statewide comparisons. (Detailed comparisons can make use of the tabular, numeric data.) Two iterations of "smoothing" were performed on seven natural hazards, so that the areas fairly proximate to (i.e. up to two counties away) some previous damaging event would be given non-zero risk and loss estimates.

Although subsidence and high risk erosion event data has been rather limited at all levels of analysis, previous editions of this plan had still considered it valid to attempt somewhat accurate estimates of potential losses to residential structures in identified subsidence and high risk erosion areas. For this updated plan, the lack of overall risk from these hazards, and the lack of a convenient procedure to assess what limited data has been obtained, means that there is little meaningful expansion that can be made upon the information already provided in those sections of the hazard analysis, in the main body of this document. Recent subsidence events data makes clear that the hazard rarely causes much damage, and the knowledge of which regions of the state had been appealing to extraction industries does not narrow or define the risks enough to produce a valid analysis. Although high risk erosion areas may be more calculable with available information, the primary data source currently available was the set of township-level high risk erosion zone maps provided by the MDEQ and described in the Great Lakes Shoreline Hazards section of the Hazards Analysis, in this plan. Yet, the history of actual hazard events shows very limited long-term effects from this hazard. **Most of the natural hazards have already had their county loss estimates provided in the new, two-page tables found in the appropriate hazard analysis sections. Attachment A supplements these tables where additional analysis was felt to be possible and valid.**

SMOOTHED DATA

Due to the fairly short timeframe of historical records from the NCDC data for Michigan (January 1996 – October 2013), some counties that have known risks from tornadoes, severe wind, hail, lightning, snowstorms, ice/sleet events, and wildfires technically did not have recorded events or damages. To avoid giving the impression of zero risk in these counties, the data was smoothed (twice) in an attempt to represent a more realistic picture of expected risk. This was accomplished by averaging estimated losses across each county and its contiguous neighbors, in order to distribute individual county losses more validly across a regional area. The data was smoothed by totaling the expected annual losses in a county with those from its adjacent counties, dividing by the total number of counties to find an average, and then assigning that average value to the central county in a new list (an "iteration"). After this process was applied once for the entire state, the calculations were then performed a second time (a "second iteration") using the averaged values from the first run. In the loss estimation tables that follow in this section for tornadoes, severe wind, hail, lightning, snowstorms, ice/sleet events, and wildfires, the smoothed data results (after two iterations) appear in the far right hand column for each county. Additionally, the maps that follow each table represent the estimated annual risk for that hazard based on the smoothed data. Geographic Information Systems were used by MSP specialists, for this process.

RELATIVE RISK

The "Relative Risk" column displays risk categories that have been derived for Michigan's natural hazards which have been able to be analyzed in terms of their property impacts. (Hazards such as extreme temperatures, which predominantly affect people, are described later.) The categories are based upon the estimated annual expected damages for each county, in a way that makes general comparisons across different hazard types. The Relative Risk is based on the expected annual losses from the smoothed data (except for flooding, which did not use a smoothing process). The relative risk categories are therefore based upon the amounts that were calculated in this risk analysis and displayed in the tables for each hazard. These categories are the following ones:

HIGH RISK – the expected annual losses are $200,000 or more.

MEDIUM RISK – the expected annual losses are between $5,000 and $199,999.

LOW RISK – the expected annual losses are less than $5,000.

Methods for Broadly Analyzing the Impacts of Natural Hazards upon Michigan Counties

FLOODING

Loss estimates for flooding were tabulated using data from the NCDC. The total number of flood events reported from January 1996 through October 2013 was divided by the number of years in the reporting period (17.83), to establish the annual number of flood events that each county has had (called "Expected Annual Events"). Then, the total dollar amount of property damage (including crop damages) was divided by the total number of events to calculate the average damage per event for each county. The per event damage amount was then multiplied by the number of expected annual events to produce the "Expected Annual Losses" amount for each county. No adjustments were made for inflation in the data for damage amounts, and Michigan total amounts were obtained separately from the NCDC source, and calculated separately, because NCDC often includes multi-county events that involved a risk of being double-counted and thus inflating the actual damages if they had been totaled within these tables. No "smoothing" process was applied to the flood hazards, because flooding generally affects specific at-risk locations, rather than randomly striking just anywhere (or everywhere) in the state, as so many of Michigan's weather hazards can.

For an example of how flood losses were estimated, consider the data for Allegan County, which had 34 such events over a 17.83 year period. This averages about 1.91 events per year, and the average amount of damage per event was $837,500 (calculated by dividing the total damages of $28,475,000 by 34 events). So the estimated damages per year comes out to ~1.91 x $837,500 = $1,597,027.

SPECIAL NOTE: The 2014 edition of the MHMP used newly collected sets of data. In addition to new U.S. Census information, a revamped online database of the National Climatic Data Center was consulted. Rather than re-use the method of flood analysis that had been present in the 2011 edition, which used CIS survey data and census information to assess the number of residential units in the flood plan, this plan uses NCDC data about actual past damages in each county to estimate the overall impacts of the flood hazard. The decennial U.S. census is of population and housing, and thus contains no information about the many types of non-residential structures located in Michigan's communities (and floodplains). The use of NCDC data therefore allows a full range of flood impacts to be included in the estimates of flood risk, based upon actual past events.
In the case of state facilities, the newest available list of facilities was compared with the location of floodplains, to produce a small list of facilities that have flood risks due to their location in or near known floodplain areas. Those facilities had their losses estimated in two ways—one by using a 1% annual chance of flooding, multiplied by a standard flood damage estimation table (originally derived from FEMA 386-2, page 4-13, since the values of these properties were known or calculated (in the confidential section of this Attachment). The other method was to apply the estimated expected flood damage amounts calculated on a county-by-county basis, as had been done for all the other significant natural hazards for which state facility loss estimates were calculated.

TORNADOES

All of Michigan's counties were considered to be at-risk from tornado damages. The risks for each county were calculated from historic data provided by the NCDC in a manner similar (at first) to the technique used to analyze annual flood risks. The total number of tornadoes reported from January 1996 through October 2013 was divided by the number of years in the reporting period (17.83), to establish the annual number of tornadoes that each county has had (called "Expected Annual Events"). Then, the total dollar amount of property damage (including crop damages) was divided by the total number of events to calculate the average damage per event for each county. The per event damage amount was then multiplied by the number of expected annual events to produce the "Expected Annual Losses" amount for each county. No adjustments were made for inflation in the data for damage amounts, but a data smoothing process (see page 640) was then used so that the results of the 17.83-year event history would better generalize to the longer-term, by having tornado damages in nearby counties included in an averaging process that adjusted the raw tornado damage values through two iterations, so that places up to two counties away from a damaging tornado would not have their risks presented as "zero" due merely to the limited historical period under consideration. In the summary table on page 68 in the main body of this plan, adjustments were made to the casualty reports, so that the large-scale human impacts of Michigan's most serious tornado events (1953 and 1965) would be included in the analysis, rather than risk underestimating the potential for the worst tornadoes to again cause such harm (as had been seen in Joplin, MO so recently).

For an example of how tornado losses were estimated, consider the data for Allegan County, which had 7 tornadoes over a 17.83 year period. This averages about 0.39 events per year, and the average amount of damage per event was $228,857 (calculated by dividing the total damages of $1,602,000 by 7 events). So the estimated damages per year comes out to ~0.39 x $228,857 = $89,849. After the tornado impacts of nearby counties were included in the assessment of risks, through two iterations of the smoothing process, Allegan County's risks were estimated to be a bit higher, at $125,334. A place such as Alger County, which would have been assessed as $0 in damages if only the original raw data had been used, instead was estimated as having $12,407 in expected annual tornado losses—considered far more accurate than a figure that implied zero risk. Not all counties had their estimated risks increased by this smoothing process. For example, Cass County had its estimated annual damages decrease as a result of the smoothing process, as it might appear that it had an unusual amount of tornado damage in the period covered by NCDC, purely by chance. However, the tables show both figures, side by side, so that readers, analysts, and local planners and emergency managers may choose whichever they decide to best represent their local risks (or some value between the two presented here).

SEVERE WINDS, HAIL, LIGHTNING, SNOWSTORMS, ICE/SLEET STORMS, AND WILDFIRES

These additional six natural hazards shared with tornadoes the characteristic of potentially being able to affect any county in Michigan (although with different probabilities of doing so). Therefore, their data were assessed in the same manner as that for tornadoes (described above), including a smoothing process. However, since no gargantuan events for these hazards have occurred that compare with the high-casualty F5 tornado events (not otherwise included in the NCDC event history period), no adjustment was made in the summary table on page 68—the estimates were instead carried forward from the calculations based on NCDC sources.

EXTREME TEMPERATURES

Although extreme temperatures had already been assessed in terms of their impacts upon human life, and their limited impacts upon property, in the hazard analysis subsection dedicated to them, some additional analysis has been included in this Attachment, where more space could be used without severely interrupting the flow of the main text's

narrative analysis. Tables are provided here to give the average number of days with temperatures below 0ºF and temperatures above 90ºF, using a 30-year Michigan data set from the Midwestern Regional Climatic Center. Based on the number of days of the extreme temperatures, the proportion of those days in a year annually was calculated by dividing each county's number into 365.4 (days per year). For instance, an average of 55.1 days of extreme cold temperatures for Iron County = 15.1% of the year (the county will continue to annually experience this many days of extreme cold temperatures). Further, a "Relative Risk" category of high, medium or low was determined based on the number of days of the extreme cold and hot temperatures for each county. An equal interval of approximately 28 counties was used to separate the three risk categories amongst the 83 counties. For extreme hot temperatures, LOW RISK = those counties experiencing 0 – 5 days of temperatures above 90°F; MEDIUM RISK = 5.1 – 9 days of temperatures above 90°F; and HIGH RISK = 9.1 or more days of temperatures above 90°F. For extreme cold temperatures, LOW RISK = those counties experiencing 0 – 9.9 days below 0°F; MEDIUM RISK = 10 – 18.9 days below 0°F; and HIGH RISK = 19 or more days below 0°F. These risk categories, unlike all those used for the hazards described above, are not based upon physical damages and therefore are not directly comparable with the other hazards.

SUBSIDENCE, SHORELINE HAZARDS, AND EARTHQUAKES

These three types of hazards were assessed in their individual chapters of the hazard analysis section in the main body of this plan. These are hazards whose history demonstrates that they have very limited physical impacts in Michigan, and it was felt that they had already been sufficiently well-addressed within their individual chapters, and the summary table on page 68. No further elaboration was considered necessary in this section—these hazards generally had no Michigan history in the NCDC source used in this risk assessment, or the event history (such as that for shoreline hazards) showed a preponderance of human impacts rather than physical property impacts. The need for this Attachment stems from the space requirements and detail needed to further analyze hazards that have a much more extensive history of causing physical damages, so it was felt that these hazards had already been well-covered in their hazard analysis chapters, and needed no further elaboration here.

GENERAL FINDINGS

General findings for the entire state have already been summarized in the table on page 68. This Attachment provides a more detailed breakdown of risks by county (as well as an assessment of the impacts upon state owned/operated facilities). In this Attachment, the main content for each county that adds to and differs from the summary tables in the hazard analysis section of this plan tends to stem from the smoothed data operations. These are clearly visible in the rightmost columns of the tables that follow. First, a brief summary of the overall Michigan risks will be worth presenting here (as shown in the Hazard Analysis Summary Table on page 68 of this plan).

To the best that current records could determine, the most frequent natural hazard in Michigan is the severe winds hazard, which averages more than 400 annual occurrences within state territory. However, as with so many hazards, most of the damage from these winds tends to come from the most severe and widespread events, rather than the hundreds that are regularly reported but result in minimal damage. When property and crop damage is considered, Michigan's natural hazards have the following ranking:

- The statewide expected annual loss due to flooding is $25,689,961.*
- The statewide expected annual loss due to severe wind damage is $25,398,151.
- The statewide expected annual loss due to tornado damage is $19,565,003.
- The statewide expected annual loss due to hail damage is $16,587,342.
- The statewide expected annual loss due to ice/sleet storm damage is $11,002,075.
- The statewide expected annual loss due to drought impacts is about $ 8,400,000.
- The statewide expected annual loss due to snowstorm damage is $ 2,288,194.*
- The statewide expected annual loss due to wildfires is $ 1,147,280.
- The statewide expected annual loss due to invasive species is probably $ 1,000,000 or more.
- The statewide expected annual loss due to geomagnetic storm effects is about $ 1,000,000 or less.
- The statewide expected annual loss due to lightning damage is $ 966,310.
- The statewide expected annual loss due to extreme cold damage is about $ 300,000.
- The statewide expected annual loss due to subsidence is about $200,000 (but recent events have involved technological, urban infrastructure breakdowns as a cause, such as broken water mains that cause road collapses, rather than subsidence within old mining areas or the hydrological causes that had been focused upon in previous editions of this plan—subsidence damages from purely natural causes are estimated to average less than $100,000 per year).
- The statewide expected annual loss from earthquakes, shoreline hazards, impacting celestial objects, and earthquakes are each estimated to be less than $100,000.

- Hazards such as extreme heat, fog, and pandemics do not have direct property damage normally associated with them. No clear method was readily available to attempt to estimate the costs of any corollary economic impacts from these hazards.

*** It must be noted that, in this new analysis and comparison of all hazards in Michigan, the most damaging hazard appear to be two types of technological hazards: fixed site hazardous materials incidents (including industrial accidents), and oil/gas pipeline accidents. Each of these was estimated to cause the same annual amount of damage—about $57 million, more than twice the amount of the top natural hazard in the list above—and each of which had, during the past 20 years, included a huge event whose costs topped $1 billion. The third most significant technological hazard was determined to be hazardous materials transportation accidents, which averaged an estimated $3 million or more per year in their impacts. Other technological hazards whose costs could not be well estimated, but which seemed to result in damages of more than $1 million per year, include infrastructure failures, major structural fires, and major transportation accidents.**

The figure for floods does not include the large amount of flood damages that are not reflected in the major events reported by NCDC. As described in the hazard analysis section of this plan, a more comprehensive estimate might result in a figure on the order of $60 million or more, but to verify this estimate in a systematic way will require new comprehensive data sources and a different method of analyzing that data than could currently be performed. Moreover, this would likely include minor events that affect only isolated households, rather than events with the capacity to cause emergency or disaster events for a community. (See the following paragraph for more explanation.)

Flood figures reported by NCDC seem to include dam failures. It is estimated that dam failures, if considered separately from all other flood causes, result in average annual damages of only about $300,000. The results of extreme cold appear comparable, based upon known large scale impacts involving frozen water mains, etc., but if individual household impacts are considered, then the damages from extreme cold would be much higher. However, as is problematic when considering structural fires or transportation accidents, events that occur predominantly on the level of an individual household are not the events that would normally be considered to have the community-wide impact that is the normal concern of emergency management (as distinct from the first responder professions such as firefighters, police, and emergency medical service providers). This plan has focused upon hazards that go beyond single households and individuals (e.g. this plan does not analyze small-scale personal crimes or routine “fender bender” car accidents, even though these add up to substantial monetary losses and personal injury), to hazards that have the real capacity to overwhelm local community response capabilities, or to otherwise cause impacts large enough to result in at least local emergency declaration. Michigan government does encourage preventive activities and hazard mitigation for these small-scale events, but in many cases, the most cost-effective form of hazard mitigation and prevention stems from public awareness, private activities, insurance-related adjustments, etc.; not necessarily community-wide or government-driven action.

Fog has not been known to cause any direct property damage. Other hazards, such as invasive species and drought, do not tend to affect specific properties in a way that lends itself to jurisdictional distinctions (although a regional breakdown has been provided in the drought chapter of the hazard analysis in the main body of this plan). The direct effects of celestial impacts are not expected to vary significantly between Michigan’s counties, and the measurement of large-scale satellite, communication, and infrastructure impacts tends to make jurisdictional distinctions inappropriate. There have been too few damaging dam failure events in Michigan to allow a precise jurisdictional loss estimate, but the collected hazard history suggests that most dams present little risk of failure. Various dams have been officially mapped, although there are many whose “hydraulic shadow” has not been plotted (and that would be the minimal information required to allow an even-handed jurisdictional comparison of risk). Somewhat better information has now been used for the much more frequent wildfire hazard; previous plans had mostly used in information pertaining to MDNR state-owned lands rather than privately owned properties with structures, but NCDC has provided enough statewide quantitative information to allow this hazard to finally start to be properly assessed using loss estimates.

Due to the still-tentative nature of many of these loss estimation procedures, it is recommended that readers consider them to be a supplement to (rather than a replacement for) the hazard analysis section of this plan.

In terms of human casualties, the most serious hazard is expected to be public health emergencies, especially pandemics. Following behind that would be extreme heat, tornadoes, severe winds, and cold. These figures are presented in the summary table on page 68 of this plan—a table that has been markedly improved since it first appeared in the previous edition of this plan.

When it comes to the comparative vulnerability of Michigan's Counties, the following table presents a ranking of counties by each of the hazards that was able to be quantitatively assessed in detail here. (However, the table only shows counties that had an estimated expected annual damage amount of at least $1 million from that corresponding hazard.)

County Ranking	Flood Risks	Tornado Risks	Severe Wind Risks	Hail Risks	Ice/Sleet Storm Risks
1	Macomb	Wayne	Ottawa	Van Buren	Macomb
2	Ottawa	Monroe	Muskegon	Berrien	Oakland
3	Allegan	Washtenaw	Kent	Cass	Wayne
4	Kalamazoo	Macomb	Wayne	Kalamazoo	St. Clair
5	Wayne	Oakland	Allegan	Shiawassee	
6	Gogebic	Lenawee		Branch	
7	Ingham			Allegan	

No Michigan Counties had annual expected losses of more than $1 million from lightning, snowstorms, wildfires, extreme temperatures, fog, shoreline hazards, dam failures, drought, earthquakes, subsidence, or celestial impacts. **Please note that technological hazards have not been considered in these comparisons.**

When comparing individual county risks (from natural hazards only) against each other, the following rankings result:

1. Macomb Flooding $5,702,748
2. Ottawa Flooding $3,153,674
3. Wayne Tornadoes $1,772,968
4. Ottawa Severe Winds $1,765,853
5. Monroe Tornadoes $1,713,165
6. Allegan Flooding $1,597,027
7. Washtenaw Hail $1,594,716
8. Berrien Hail $1,573,923
9. Cass Hail $1,542,861
10. Kalamazoo Hail $1,533,810
11. Shiawassee Hail $1,532,297
12. Macomb Ice/Sleet Storms $1,507,568
13. Muskegon Severe Winds $1,423,861
14. Kalamazoo Flooding $1,361,750
15. Washtenaw Tornadoes $1,356,121
16. Kent Severe Winds $1,344,902
17. Oakland Ice/Sleet Storms $1,336,891
18. Wayne Ice/Sleet Storms $1,290,511
19. Wayne Flooding $1,259,675
20. Macomb Tornadoes $1,213,402
21. Wayne Severe Winds $1,182,425
22. Oakland Tornadoes $1,139,969
23. Allegan Severe Winds $1,102,763
24. Branch Hail $1,102,756
25. St. Clair Ice/Sleet Storms $1,092,605
26. Allegan Hail $1,082,724
27. Lenawee Tornadoes $1,070,348
28. Gogebic Flooding $1,066,237
29. Ingham Flooding $1,003,646

Although these rankings may appear to be clear-cut, keep in mind that they do not include a consideration of human casualties, local resources (for example, although more snow falls in the Upper Peninsula, it causes less damage there), and other considerations beyond property damage reports. They are also based upon less than 20 years of data. It will be appropriate for these statistics to be reviewed by multiple agencies, including the involved local emergency management programs, before they are considered appropriate for use in prioritizing state assistance in hazard mitigation activities. (In addition, certain types of hazards are more susceptible to available mitigation options, and therefore any prioritization from this plan cannot be based exclusively upon the extent of perceived property risk.)

Loss Estimation Tables for Counties (and general critical infrastructure vulnerability)

1. Michigan Counties – Flooding
2. Michigan Counties – Tornadoes
3. Michigan Counties – Severe Winds
4. Michigan Counties – Hail
5. Michigan Counties – Lightning
6. Michigan Counties – Snowstorms
7. Michigan Counties – Ice/Sleet Storms
8. Michigan Counties – Wildfires
9. Michigan Counties – Extreme Cold Temperatures (Risk / probability)
10. Michigan Counties – Extreme Hot Temperatures (Risk / probability)
11. General Natural Hazard Vulnerability: Lifelines (utility and transportation infrastructure)

Loss Estimation for the State of Michigan: Flooding

COUNTY	Population*	Relative Risk	Number of Riverine Flood Events: 1996-2013 (NCDC)	Expected Annual Events	NCDC Total Historic Riverine Flood Damage ($millions)	Expected Annual Losses ($)
Alcona	10,942	MEDIUM	4	0.22	0.11	6,169
Alger	9,601	LOW	6	0.34	0.00	0
Allegan	111,408	HIGH	34	1.91	28.48	1,597,027
Alpena	29,598	LOW	1	0.06	0.00	0
Antrim	23,580	LOW	1	0.06	0.00	0
Arenac	15,899	MEDIUM	13	0.73	0.10	5,496
Baraga	8,860	MEDIUM	14	0.79	2.04	114,638
Barry	59,173	HIGH	29	1.63	13.97	783,511
Bay	107,771	HIGH	24	1.35	9.05	507,291
Benzie	17,525	LOW	1	0.06	0.00	0
Berrien	156,813	HIGH	20	1.12	6.91	387,549
Branch	45,248	HIGH	14	0.79	6.16	345,485
Calhoun	136,146	HIGH	27	1.51	13.13	736,399
Cass	52,293	HIGH	21	1.18	6.66	373,528
Charlevoix	25,949	LOW	1	0.06	0.00	112
Cheboygan	26,152	LOW	3	0.17	0.03	1,570
Chippewa	38,520	MEDIUM	6	0.34	0.13	7,011
Clare	30,926	HIGH	8	0.45	4.45	249,579
Clinton	75,382	HIGH	26	1.46	12.87	721,817
Crawford	14,074	LOW	1	0.06	0.01	337
Delta	37,069	MEDIUM	22	1.23	0.81	45,149
Dickinson	26,168	LOW	11	0.62	0.03	1,739
Eaton	107,759	HIGH	25	1.40	12.77	716,209
Emmet	32,694	LOW	1	0.06	0.02	1,010
Genesee	425,790	HIGH	38	2.13	13.91	780,146
Gladwin	25,692	MEDIUM	7	0.39	0.10	5,777
Gogebic	16,427	HIGH	13	0.73	19.01	1,066,237
Gd Traverse	86,986	MEDIUM	6	0.34	1.81	101,739
Gratiot	42,476	HIGH	26	1.46	10.82	606,842
Hillsdale	46,688	HIGH	20	1.12	6.31	353,898
Houghton	36,628	MEDIUM	17	0.95	2.90	162,647
Huron	33,118	HIGH	23	1.29	6.32	354,403

Loss Estimation for the State of Michigan: Flooding – cont.

COUNTY	Population*	Relative Risk	Number of Riverine Flood Events: 1996-2013 (NCDC)	Expected Annual Events	NCDC Total Historic Riverine Flood Damage ($millions)	Expected Annual Losses ($)
Ingham	280,895	HIGH	26	1.46	17.90	1,003,646
Ionia	63,905	HIGH	21	1.18	14.57	817,162
Iosco	25,887	LOW	3	0.17	0.00	168
Iron	11,817	MEDIUM	10	0.56	0.65	36,175
Isabella	70,311	HIGH	27	1.51	14.83	831,464
Jackson	160,248	HIGH	25	1.40	11.43	640,774
Kalamazoo	250,331	HIGH	27	1.51	24.28	1,361,750
Kalkaska	17,153	LOW	2	0.11	0.02	1,122
Kent	602,622	HIGH	38	2.13	11.14	624,790
Keweenaw	2,156	MEDIUM	7	0.39	0.13	7,403
Lake	11,539	HIGH	8	0.45	6.89	386,427
Lapeer	88,319	HIGH	28	1.57	16.78	941,110
Leelanau	21,708	LOW	2	0.11	0.05	2,804
Lenawee	99,892	HIGH	36	2.02	6.81	381,941
Livingston	180,967	MEDIUM	17	0.95	1.30	73,135
Luce	6,631	LOW	3	0.17	0.00	0
Mackinac	11,113	LOW	5	0.28	0.06	3,253
Macomb	840,978	HIGH	34	1.91	101.68	5,702,748
Manistee	24,733	MEDIUM	8	0.45	1.52	85,250
Marquette	67,077	HIGH	27	1.51	14.73	825,855
Mason	28,705	HIGH	13	0.73	8.21	460,179
Mecosta	42,798	HIGH	27	1.51	16.56	928,772
Menominee	24,029	MEDIUM	5	0.28	0.85	47,672
Midland	83,629	HIGH	25	1.40	8.83	495,233
Missaukee	14,849	MEDIUM	3	0.17	0.16	8,974
Monroe	152,021	HIGH	29	1.63	9.89	554,683
Montcalm	63,342	HIGH	24	1.35	10.82	606,842
Montmorency	9,765	LOW	1	0.06	0.00	0
Muskegon	172,188	HIGH	28	1.57	13.49	756,590
Newaygo	48,460	HIGH	10	0.56	6.71	376,332
Oakland	1,202,362	MEDIUM	22	1.23	2.71	151,767

Loss Estimation for the State of Michigan: Flooding – cont.

COUNTY	Population*	Relative Risk	Number of Riverine Flood Events: 1996-2013 (NCDC)	Expected Annual Events	NCDC Total Historic Riverine Flood Damage ($millions)	Expected Annual Losses ($)
Oceana	26,570	HIGH	9	0.50	5.11	286,596
Ogemaw	21,699	MEDIUM	3	0.17	0.15	8,413
Ontonagon	6,780	MEDIUM	12	0.67	0.82	45,822
Osceola	23,528	HIGH	11	0.62	5.83	326,697
Oscoda	8,640	LOW	3	0.17	0.00	168
Otsego	24,164	LOW	1	0.06	0.00	168
Ottawa	263,801	HIGH	34	1.91	56.23	3,153,674
Presque Isle	13,376	LOW		0.00	0.00	0
Roscommon	24,449	LOW	1	0.06	0.00	224
Saginaw	200,169	HIGH	48	2.69	9.84	551,711
St. Clair	163,040	HIGH	24	1.35	9.58	537,297
St. Joseph	61,295	HIGH	18	1.01	6.66	373,528
Sanilac	43,114	HIGH	21	1.18	8.25	462,423
Schoolcraft	8,485	LOW	3	0.17	0.00	0
Shiawassee	70,648	HIGH	27	1.51	7.33	411,161
Tuscola	55,729	HIGH	32	1.79	14.13	792,485
Van Buren	76,258	HIGH	24	1.35	10.90	611,497
Washtenaw	344,791	HIGH	30	1.68	13.05	731,913
Wayne	1,820,584	HIGH	59	3.31	22.46	1,259,675
Wexford	32,735	MEDIUM	10	0.56	0.87	48,906
MI TOTAL	9,883,640		925	51.88	458.05	25,689,961

**Notes: ***2010 Census.

Loss Estimation for the State of Michigan: Tornadoes

COUNTY	Population*	Relative Risk	Number of Tornadoes: 1996-2013 (NCDC)	Expected Annual Events	NCDC Total Historic Tornado Damage ($millions)	Expected Annual Losses ($)	Expected Annual Losses ($)- Smoothed Data
Alcona	10,942	MEDIUM	3	0.17	0.32	17,667	33,006
Alger	9,601	MEDIUM	1	0.06	0.00	0	12,407
Allegan	111,408	MEDIUM	7	0.39	1.60	89,849	125,334
Alpena	29,598	MEDIUM	4	0.22	0.49	27,538	29,157
Antrim	23,580	MEDIUM	2	0.11	0.00	224	14,185
Arenac	15,899	MEDIUM	3	0.17	0.02	897	30,309
Baraga	8,860	MEDIUM		0.00	0.00	0	29,115
Barry	59,173	HIGH	2	0.11	0.30	16,826	293,296
Bay	107,771	MEDIUM	4	0.22	0.17	9,534	101,478
Benzie	17,525	LOW		0.00	0.00	0	4,910
Berrien	156,813	MEDIUM	7	0.39	2.11	118,340	122,728
Branch	45,248	MEDIUM	2	0.11	0.05	2,804	143,545
Calhoun	136,146	HIGH	4	0.22	3.48	194,896	311,684
Cass	52,293	MEDIUM	6	0.34	5.90	330,903	112,945
Charlevoix	25,949	MEDIUM	1	0.06	0.00	0	8,848
Cheboygan	26,152	MEDIUM	2	0.11	0.03	1,683	10,597
Chippewa	38,520	LOW	1	0.06	0.20	11,217	2,854
Clare	30,926	MEDIUM	3	0.17	0.22	12,339	27,461
Clinton	75,382	HIGH	2	0.11	0.60	33,651	425,733
Crawford	14,074	MEDIUM	4	0.22	0.06	3,365	22,242
Delta	37,069	MEDIUM	4	0.22	0.04	2,131	32,180
Dickinson	26,168	MEDIUM	6	0.34	7.13	400,056	79,385
Eaton	107,759	HIGH	8	0.45	50.58	2,836,904	568,341
Emmet	32,694	LOW	1	0.06	0.00	0	1,026
Genesee	425,790	HIGH	18	1.01	18.51	1,038,138	529,851
Gladwin	25,692	MEDIUM	2	0.11	0.09	5,048	32,720
Gogebic	16,427	MEDIUM	1	0.06	0.03	1,402	19,905
Gd Traverse	86,986	MEDIUM		0.00	0.00	0	7,231
Gratiot	42,476	HIGH	5	0.28	0.70	39,484	237,099
Hillsdale	46,688	HIGH	3	0.17	0.35	19,686	410,980
Houghton	36,628	MEDIUM		0.00	0.00	0	11,881
Huron	33,118	MEDIUM	5	0.28	0.42	23,275	106,419

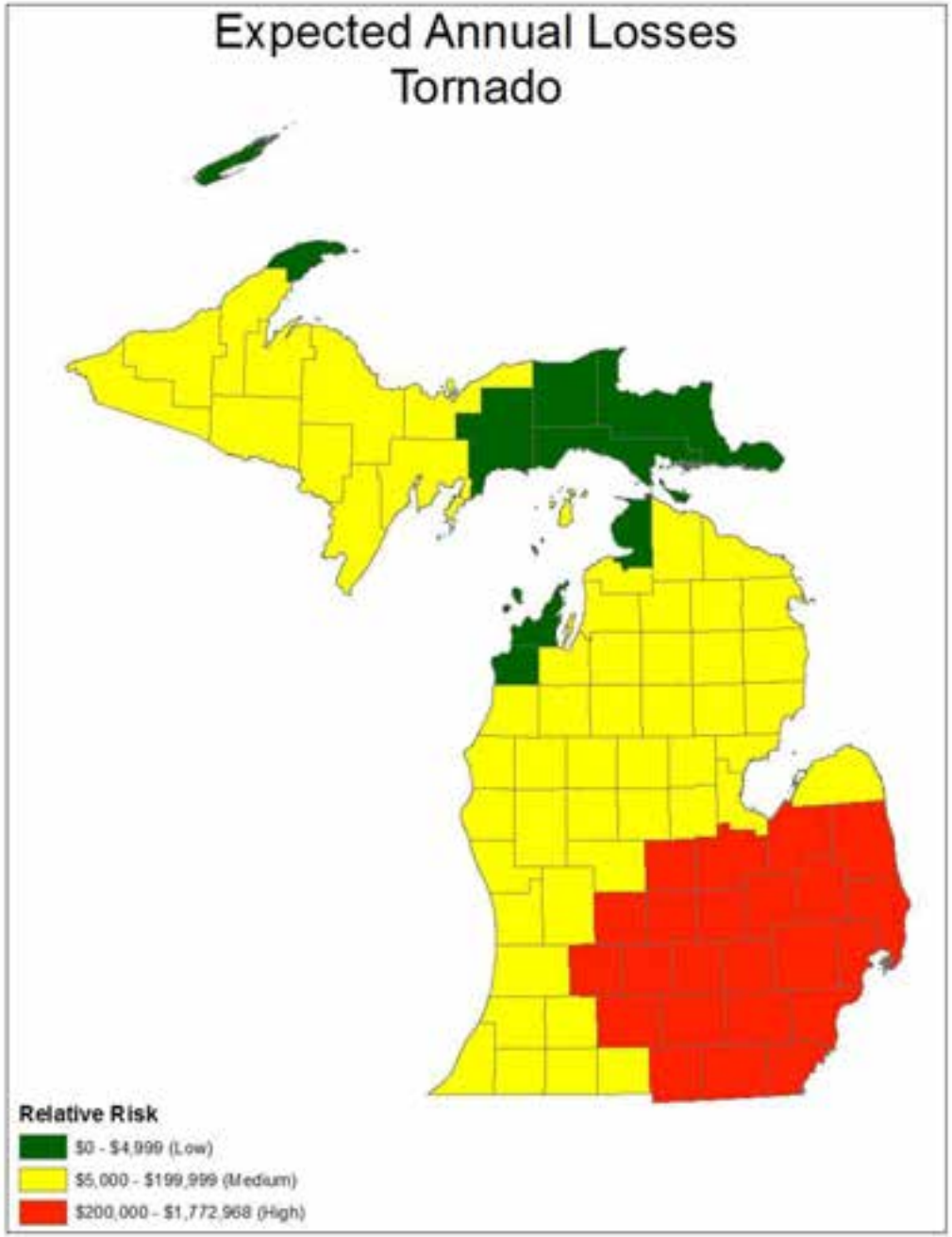
Loss Estimation for the State of Michigan: Tornadoes – cont.

COUNTY	Population*	Relative Risk	Number of Tornadoes: 1996-2013 (NCDC)	Expected Annual Events	NCDC Total Historic Tornado Damage ($millions)	Expected Annual Losses ($)	Expected Annual Losses ($)- Smoothed Data
Ingham	280,895	HIGH	7	0.39	21.05	1,180,595	620,397
Ionia	63,905	HIGH	2	0.11	0.17	9,254	316,417
Iosco	25,887	MEDIUM	1	0.06	0.08	4,206	26,181
Iron	11,817	MEDIUM	1	0.06	0.02	841	31,316
Isabella	70,311	MEDIUM	5	0.28	0.73	40,662	33,922
Jackson	160,248	HIGH	2	0.11	0.75	42,064	677,226
Kalamazoo	250,331	MEDIUM	7	0.39	0.83	46,691	171,424
Kalkaska	17,153	MEDIUM	3	0.17	1.10	61,694	17,911
Kent	602,622	MEDIUM	7	0.39	0.60	33,651	129,786
Keweenaw	2,156	LOW	1	0.06	0.00	0	196
Lake	11,539	MEDIUM	1	0.06	0.20	11,217	12,796
Lapeer	88,319	HIGH	9	0.50	1.88	105,440	636,825
Leelanau	21,708	LOW	1	0.06	0.02	1,122	2,966
Lenawee	99,892	HIGH	4	0.22	0.58	32,529	1,070,348
Livingston	180,967	HIGH	8	0.45	10.22	573,191	816,072
Luce	6,631	LOW	1	0.06	0.00	0	1,917
Mackinac	11,113	LOW	1	0.06	0.00	0	2,200
Macomb	840,978	HIGH	4	0.22	30.80	1,727,426	1,213,402
Manistee	24,733	MEDIUM	1	0.06	0.02	841	7,027
Marquette	67,077	MEDIUM	4	0.22	0.02	841	45,633
Mason	28,705	MEDIUM	1	0.06	0.00	0	8,366
Mecosta	42,798	MEDIUM	1	0.06	1.20	67,302	22,698
Menominee	24,029	MEDIUM	2	0.11	0.03	1,402	65,166
Midland	83,629		3	0.17	0.23	12,619	69,956
Missaukee	14,849	MEDIUM	1	0.06	0.00	0	18,119
Monroe	152,021	MEDIUM	7	0.39	60.20	3,376,500	1,713,165
Montcalm	63,342	HIGH	2	0.11	0.18	9,927	151,124
Montmorency	9,765	MEDIUM	3	0.17	0.21	11,778	25,636
Muskegon	172,188	MEDIUM	3	0.17	0.05	2,804	18,121
Newaygo	48,460	MEDIUM	4	0.22	0.07	4,038	16,678
Oakland	1,202,362	MEDIUM	6	0.34	6.92	387,942	1,139,969

Loss Estimation for the State of Michigan: Tornadoes – cont.

COUNTY	Population*	Relative Risk	Number of Tornadoes: 1996-2013 (NCDC)	Expected Annual Events	NCDC Total Historic Tornado Damage ($millions)	Expected Annual Losses ($)	Expected Annual Losses ($)- Smoothed Data
Oceana	26,570	MEDIUM		0.00	0.00	0	10,152
Ogemaw	21,699	MEDIUM	2	0.11	0.08	4,206	24,971
Ontonagon	6,780	MEDIUM	1	0.06	0.02	1,122	15,027
Osceola	23,528	MEDIUM	5	0.28	0.61	34,324	19,591
Oscoda	8,640	MEDIUM	4	0.22	2.89	162,086	31,824
Otsego	24,164	MEDIUM	1	0.06	0.01	617	16,611
Ottawa	263,801	MEDIUM	3	0.17	0.26	14,582	25,894
Presque Isle	13,376	MEDIUM	2	0.11	0.00	0	21,042
Roscommon	24,449	MEDIUM		0.00	0.00	0	20,390
Saginaw	200,169	HIGH	13	0.73	6.31	354,094	212,944
St. Clair	163,040	HIGH	7	0.39	0.90	50,196	621,653
St. Joseph	61,295	MEDIUM	6	0.34	0.82	46,113	145,920
Sanilac	43,114	HIGH	5	0.28	0.45	24,958	256,211
Schoolcraft	8,485	LOW		0.00	0.00	0	1,344
Shiawassee	70,648	HIGH	9	0.50	0.66	36,736	437,325
Tuscola	55,729	HIGH	8	0.45	1.06	59,450	209,156
Van Buren	76,258	MEDIUM	4	0.22	0.12	6,730	99,908
Washtenaw	344,791	HIGH	5	0.28	12.60	706,394	1,356,121
Wayne	1,820,584	HIGH	3	0.17	90.75	5,089,736	1,772,968
Wexford	32,735	MEDIUM	1	0.06	0.01	449	10,319
MI TOTAL	9,883,640		292	16.38	348.84	19,565,003	

Notes: *2010 Census.


Expected Annual Losses
Tornado
Relative Risk
$0 - $4,999 (Low)
$5,000 - $199,999 (Medium)
$200,000 - $1,772,968 (High)

Loss Estimation for the State of Michigan: Severe Winds

COUNTY	Population*	Relative Risk	Number of Damaging Wind events: 1996-2013 (NCDC)	Expected Annual Events	Adjusted Historic Wind Damage ($) (NCDC)	Expected Annual Losses ($)	Expected Annual Losses ($)- Smoothed Data
Alcona	10,942	MEDIUM	42	2.36	93,000	5,216	11,269
Alger	9,601	MEDIUM	45	2.52	1,252,000	70,219	97,825
Allegan	111,408	HIGH	246	13.80	3,116,000	174,762	1,102,763
Alpena	29,598	MEDIUM	40	2.24	190,000	10,656	10,465
Antrim	23,580	MEDIUM	55	3.08	231,000	12,956	12,520
Arenac	15,899	MEDIUM	28	1.57	222,500	12,479	70,226
Baraga	8,860	MEDIUM	49	2.75	463,500	25,996	65,695
Barry	59,173	HIGH	201	11.27	2,587,000	145,093	823,604
Bay	107,771	MEDIUM	105	5.89	4,986,000	279,641	180,467
Benzie	17,525	MEDIUM	24	1.35	158,000	8,861	23,280
Berrien	156,813	MEDIUM	178	9.98	986,000	55,300	104,169
Branch	45,248	HIGH	162	9.09	422,500	23,696	372,288
Calhoun	136,146	HIGH	156	8.75	29,505,000	1,654,795	474,862
Cass	52,293	MEDIUM	137	7.68	1,223,000	68,592	199,084
Charlevoix	25,949	MEDIUM	35	1.96	273,000	15,311	12,102
Cheboygan	26,152	MEDIUM	30	1.68	181,000	10,151	15,776
Chippewa	38,520	MEDIUM	31	1.74	75,500	4,234	34,559
Clare	30,926	MEDIUM	41	2.30	534,500	29,978	92,506
Clinton	75,382	HIGH	196	10.99	3,177,000	178,183	468,870
Crawford	14,074	MEDIUM	28	1.57	252,000	14,133	12,963
Delta	37,069	MEDIUM	68	3.81	5,236,200	293,674	106,117
Dickinson	26,168	MEDIUM	60	3.37	878,000	49,243	73,247
Eaton	107,759	HIGH	196	10.99	5,465,000	306,506	536,231
Emmet	32,694	MEDIUM	35	1.96	281,000	15,760	12,404
Genesee	425,790	HIGH	384	21.54	9,972,000	559,282	483,400
Gladwin	25,692	MEDIUM	31	1.74	256,500	14,386	92,556
Gogebic	16,427	MEDIUM	83	4.66	1,171,500	65,704	72,778
Gd. Traverse	86,986	MEDIUM	38	2.13	301,500	16,910	19,772
Gratiot	42,476	HIGH	162	9.09	2,523,000	141,503	410,084
Hillsdale	46,688	HIGH	150	8.41	562,500	31,548	390,922
Houghton	36,628	MEDIUM	64	3.59	1,138,500	63,853	59,213
Huron	33,118	HIGH	118	6.62	3,091,000	173,360	236,593

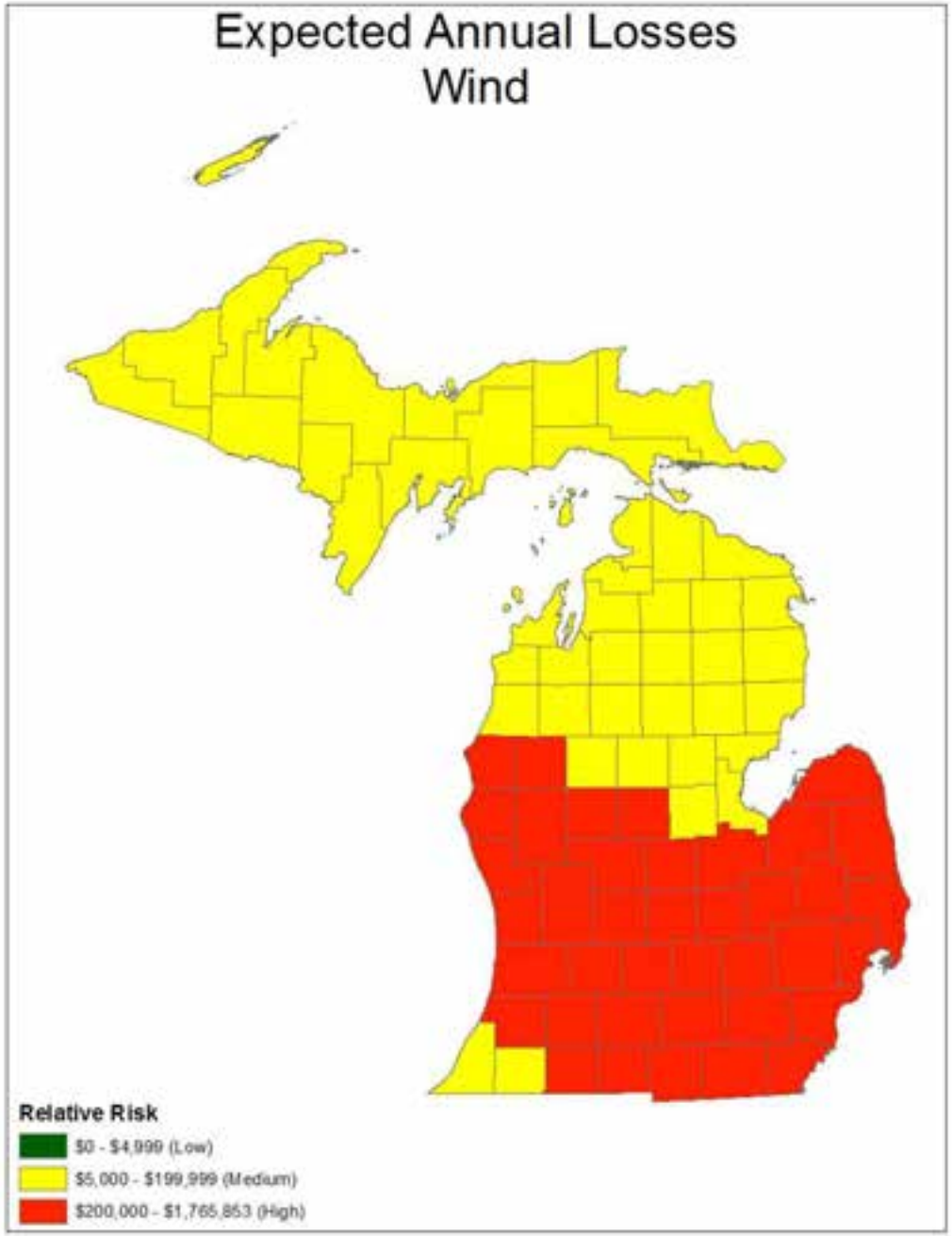
Loss Estimation for the State of Michigan: Severe Winds – cont.

COUNTY	Population*	Relative Risk	Number of Damaging Wind events: 1996-2013 (NCDC)	Expected Annual Events	Adjusted Historic Wind Damage ($) (NCDC)	Expected Annual Losses ($)	Expected Annual Losses ($)- Smoothed Data
Ingham	280,895	HIGH	210	11.78	6,145,000	344,644	363,704
Ionia	63,905	HIGH	184	10.32	2,486,000	139,428	738,863
Iosco	25,887	MEDIUM	36	2.02	151,000	8,469	23,462
Iron	11,817	MEDIUM	55	3.08	2,070,500	116,125	67,590
Isabella	70,311	HIGH	54	3.03	1,280,000	71,789	223,385
Jackson	160,248	HIGH	118	6.62	1,240,000	69,546	438,144
Kalamazoo	250,331	HIGH	124	6.95	5,953,000	333,875	511,684
Kalkaska	17,153	MEDIUM	28	1.57	63,000	3,533	15,684
Kent	602,622	HIGH	227	12.73	83,624,000	4,690,073	1,344,902
Keweenaw	2,156	MEDIUM	38	2.13	341,000	19,125	49,519
Lake	11,539	HIGH	31	1.74	2,144,000	120,247	244,510
Lapeer	88,319	HIGH	277	15.54	5,496,000	308,245	630,256
Leelanau	21,708	MEDIUM	33	1.85	131,000	7,347	13,109
Lenawee	99,892	HIGH	216	12.11	7,254,000	406,842	673,235
Livingston	180,967	HIGH	219	12.28	3,319,500	186,175	547,944
Luce	6,631	MEDIUM	36	2.02	172,000	9,647	66,961
Mackinac	11,113	MEDIUM	24	1.35	89,000	4,992	45,375
Macomb	840,978	HIGH	279	15.65	22,953,000	1,287,325	966,132
Manistee	24,733	MEDIUM	45	2.52	538,500	30,202	53,212
Marquette	67,077	MEDIUM	119	6.67	619,750	34,759	84,246
Mason	28,705	HIGH	48	2.69	1,692,000	94,896	336,081
Mecosta	42,798	HIGH	40	2.24	636,110	35,676	322,431
Menominee	24,029	MEDIUM	64	3.59	124,500	6,983	87,809
Midland	83,629	MEDIUM	88	4.94	2,828,000	158,609	175,648
Missaukee	14,849	MEDIUM	20	1.12	301,000	16,882	25,475
Monroe	152,021	HIGH	198	11.10	5,030,000	282,109	957,589
Montcalm	63,342	HIGH	183	10.26	16,454,000	922,827	622,814
Montmorency	9,765	MEDIUM	38	2.13	240,000	13,460	10,910
Muskegon	172,188	HIGH	191	10.71	34,521,250	1,936,133	1,423,861
Newaygo	48,460	HIGH	51	2.86	2,158,000	121,032	664,271
Oakland	1,202,362	HIGH	414	23.22	16,319,000	915,255	863,500

Loss Estimation for the State of Michigan: Severe Winds – cont.

COUNTY	Population*	Relative Risk	Number of Damaging Wind events: 1996-2013 (NCDC)	Expected Annual Events	Adjusted Historic Wind Damage ($) (NCDC)	Expected Annual Losses ($)	Expected Annual Losses ($)- Smoothed Data
Oceana	26,570	HIGH	38	2.13	4,657,000	261,189	717,050
Ogemaw	21,699	MEDIUM	51	2.86	450,530	25,268	27,750
Ontonagon	6,780	MEDIUM	59	3.31	1,117,000	62,647	68,971
Osceola	23,528	MEDIUM	32	1.79	589,500	33,062	189,604
Oscoda	8,640	MEDIUM	27	1.51	168,000	9,422	11,977
Otsego	24,164	MEDIUM	38	2.13	180,500	10,123	11,774
Ottawa	263,801	HIGH	209	11.72	49,047,000	2,750,813	1,765,853
Presque Isle	13,376	MEDIUM	26	1.46	80,000	4,487	9,664
Roscommon	24,449	MEDIUM	51	2.86	233,000	13,068	25,749
Saginaw	200,169	HIGH	292	16.38	7,935,000	445,036	278,417
St. Clair	163,040	HIGH	286	16.04	6,684,000	374,874	652,701
St. Joseph	61,295	HIGH	145	8.13	648,750	36,385	277,727
Sanilac	43,114	HIGH	92	5.16	2,733,500	153,309	356,225
Schoolcraft	8,485	MEDIUM	35	1.96	3,288,000	184,408	89,305
Shiawassee	70,648	HIGH	230	12.90	5,055,000	283,511	329,396
Tuscola	55,729	HIGH	145	8.13	3,290,950	184,574	305,362
Van Buren	76,258	HIGH	114	6.39	1,551,000	86,988	393,170
Washtenaw	344,791	HIGH	300	16.83	13,335,000	747,897	833,054
Wayne	1,820,584	HIGH	306	17.16	64,495,000	3,617,218	1,182,425
Wexford	32,735	MEDIUM	36	2.02	194,000	10,881	34,790
MI TOTAL	9,883,640		7,324	410.77	452,849,030	25,398,151	

Notes: *2010 Census


Expected Annual Losses
Wind
Relative Risk
$0 - $4,999 (Low)
$5,000 - $199,999 (Medium)
$200,000 - $1,765,853 (High)

Loss Estimation for the State of Michigan: Hail

COUNTY	Population*	Relative Risk	Number of Damaging Hailstorms: 1996-2013 (NCDC)	Expected Annual Events	Historic Hailstorm Damage ($) (NCDC)	Expected Annual Losses ($)	Expected Annual Losses ($)- Smoothed Data
Alcona	10,942	MEDIUM	41	2.30	0	0	11,544
Alger	9,601	HIGH	40	2.24	5,000	280	401,951
Allegan	111,408	HIGH	47	2.64	1,024,000	57,431	1,082,724
Alpena	29,598	MEDIUM	28	1.57	0	0	24,509
Antrim	23,580	LOW	25	1.40	30,000	1,683	531
Arenac	15,899	LOW	31	1.74	0	0	1,238
Baraga	8,860	HIGH	31	1.74	0	0	530,590
Barry	59,173	HIGH	39	2.19	565,000	31,688	818,667
Bay	107,771	MEDIUM	41	2.30	0	0	9,555
Benzie	17,525	LOW	9	0.50	0	0	1,662
Berrien	156,813	HIGH	39	2.19	1,308,000	73,360	1,573,923
Branch	45,248	HIGH	54	3.03	1,000,000	56,085	1,102,756
Calhoun	136,146	HIGH	34	1.91	610,000	34,212	855,720
Cass	52,293	HIGH	23	1.29	12,000	673	1,542,861
Charlevoix	25,949	MEDIUM	26	1.46	0	0	7,013
Cheboygan	26,152	MEDIUM	15	0.84	0	0	16,547
Chippewa	38,520	LOW	22	1.23	0	0	766
Clare	30,926	MEDIUM	29	1.63	565,000	31,688	12,191
Clinton	75,382	MEDIUM	26	1.46	265,000	14,863	99,012
Crawford	14,074	LOW	18	1.01	0	0	4,052
Delta	37,069	HIGH	63	3.53	4,000	224	583,925
Dickinson	26,168	HIGH	54	3.03	225,000	12,619	747,931
Eaton	107,759	HIGH	41	2.30	760,000	42,625	375,589
Emmet	32,694	MEDIUM	15	0.84	100,000	5,609	11,525
Genesee	425,790	MEDIUM	157	8.81	0	0	25,647
Gladwin	25,692	MEDIUM	29	1.63	0	0	6,401
Gogebic	16,427	HIGH	45	2.52	750,000	42,064	239,173
Gd. Traverse	86,986	LOW	18	1.01	0	0	1,723
Gratiot	42,476	MEDIUM	25	1.40	265,000	14,863	79,545
Hillsdale	46,688	HIGH	35	1.96	2,000,000	112,170	524,431
Houghton	36,628	HIGH	43	2.41	10,000	561	327,459
Huron	33,118	LOW	54	3.03	5,000	280	2,617

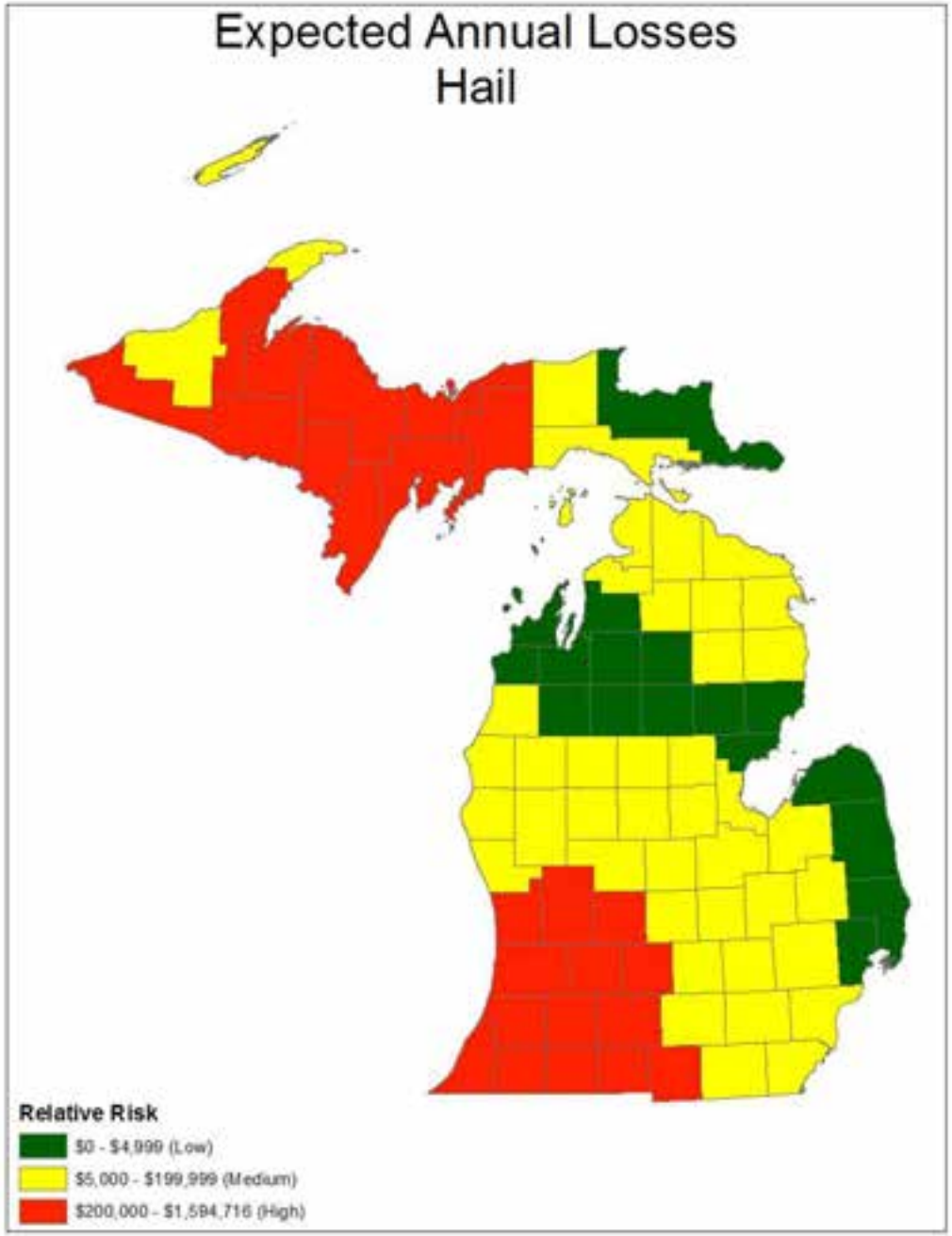
Loss Estimation for the State of Michigan: Hail – cont.

COUNTY	Population *	Relative Risk	Number of Damaging Hailstorms: 1996-2013 (NCDC)	Expected Annual Events	Historic Hailstorm Damage ($) (NCDC)	Expected Annual Losses ($)	Expected Annual Losses ($)- Smoothed Data
Ingham	280,895	MEDIUM	40	2.24	635,000	35,614	61,677
Ionia	63,905	HIGH	14	0.79	4,275,000	239,764	281,789
Iosco	25,887	LOW	47	2.64	0	0	0
Iron	11,817	HIGH	42	2.36	4,100,000	229,950	464,236
Isabella	70,311	MEDIUM	33	1.85	315,000	17,667	40,688
Jackson	160,248	MEDIUM	37	2.08	605,000	33,932	165,200
Kalamazoo	250,331	HIGH	54	3.03	130,050,000	7,293,887	1,533,810
Kalkaska	17,153	LOW	9	0.50	0	0	1,645
Kent	602,622	HIGH	74	4.15	15,322,000	859,338	518,948
Keweenaw	2,156	MEDIUM	4	0.22	0	0	23,191
Lake	11,539	MEDIUM	15	0.84	175,000	9,815	25,774
Lapeer	88,319	MEDIUM	59	3.31	0	0	7,373
Leelanau	21,708	LOW	29	1.63	55,000	3,085	960
Lenawee	99,892	MEDIUM	91	5.10	2,150,000	120,583	44,998
Livingston	180,967	MEDIUM	45	2.52	0	0	38,707
Luce	6,631	MEDIUM	15	0.84	0	0	145,979
Mackinac	11,113	MEDIUM	12	0.67	0	0	6,954
Macomb	840,978	LOW	122	6.84	2,000	112	1,745
Manistee	24,733	MEDIUM	19	1.07	35,000	1,963	5,052
Marquette	67,077	HIGH	114	6.39	64,647,000	3,625,743	772,807
Mason	28,705	MEDIUM	16	0.90	105,000	5,889	32,470
Mecosta	42,798	MEDIUM	22	1.23	475,000	26,640	51,549
Menominee	24,029	HIGH	54	3.03	100,000	5,609	790,128
Midland	83,629	MEDIUM	72	4.04	1,000	56	23,767
Missaukee	14,849	LOW	14	0.79	0	0	4,713
Monroe	152,021	MEDIUM	74	4.15	0	0	26,617
Montcalm	63,342	MEDIUM	25	1.40	1,280,000	71,789	106,737
Montmorency	9,765	MEDIUM	25	1.40	0	0	19,274
Muskegon	172,188	MEDIUM	40	2.24	675,000	37,858	150,609
Newaygo	48,460	MEDIUM	28	1.57	395,000	22,154	80,669
Oakland	1,202,362	MEDIUM	147	8.24	11,000	617	16,291

Loss Estimation for the State of Michigan: Hail – cont.

COUNTY	Population*	Relative Risk	Number of Damaging Hailstorms: 1996-2013 (NCDC)	Expected Annual Events	Historic Hailstorm Damage ($) (NCDC)	Expected Annual Losses ($)	Expected Annual Losses ($)- Smoothed Data
Oceana	26,570	MEDIUM	21	1.18	315,000	17,667	71,143
Ogemaw	21,699	LOW	35	1.96	0	0	1,291
Ontonagon	6,780	MEDIUM	45	2.52	0	0	190,906
Osceola	23,528	MEDIUM	14	0.79	145,000	8,132	26,241
Oscoda	8,640	MEDIUM	34	1.91	0	0	8,180
Otsego	24,164	MEDIUM	36	2.02	0	0	7,529
Ottawa	263,801	HIGH	53	2.97	794,000	44,532	617,665
Presque Isle	13,376	MEDIUM	26	1.46	3,800,000	213,124	38,448
Roscommon	24,449	LOW	31	1.74	0	0	3,254
Saginaw	200,169	MEDIUM	86	4.82	300	17	30,861
St. Clair	163,040	LOW	71	3.98	125,000	7,011	2,864
St. Joseph	61,295	HIGH	41	2.30	0	0	1,532,297
Sanilac	43,114	LOW	49	2.75	165,000	9,254	2,875
Schoolcraft	8,485	HIGH	32	1.79	100,000	5,609	291,477
Shiawassee	70,648	MEDIUM	36	2.02	4,800,000	269,209	59,779
Tuscola	55,729	MEDIUM	65	3.65	0	0	12,776
Van Buren	76,258	HIGH	26	1.46	50,585,000	2,837,072	1,594,716
Washtenaw	344,791	MEDIUM	154	8.64	10,000	561	28,962
Wayne	1,820,584	MEDIUM	146	8.19	7,000	393	10,977
Wexford	32,735	LOW	22	1.23	0	0	4,815
MI TOTAL	9,883,640		3,612	202.58	295,752,300	16,587,342	

Notes: *2010 Census


Expected Annual Losses
Hail
Relative Risk
$0 - $4,999 (Low)
$5,000 - $199,999 (Medium)
$200,000 - $1,594,716 (High)

Loss Estimation for the State of Michigan: Lightning

COUNTY	Population*	Relative Risk	Number of Damaging Lightning Events: 1996-2013 (NCDC)	Expected Annual Events	Historic Lightning Damage ($) (NCDC)	Expected Annual Losses ($)	Expected Annual Losses ($)- Smoothed Data
Alcona	10,942	LOW		0.00		0	1,417
Alger	9,601	LOW	2	0.11		0	1,754
Allegan	111,408	MEDIUM		0.00		0	9,347
Alpena	29,598	LOW	1	0.06		0	1,789
Antrim	23,580	MEDIUM	2	0.11	80,000	4,487	5,129
Arenac	15,899	LOW	1	0.06	500	28	1,410
Baraga	8,860	LOW		0.00		0	1,717
Barry	59,173	MEDIUM	1	0.06		0	5,571
Bay	107,771	MEDIUM	5	0.28	63,000	3,533	6,172
Benzie	17,525	LOW	1	0.06		0	2,222
Berrien	156,813	MEDIUM	3	0.17	840,000	47,112	13,953
Branch	45,248	LOW		0.00		0	3,075
Calhoun	136,146	MEDIUM	1	0.06	11,000	617	6,957
Cass	52,293	MEDIUM		0.00		0	9,226
Charlevoix	25,949	MEDIUM	1	0.06		0	5,290
Cheboygan	26,152	LOW	2	0.11	75,000	4,206	3,992
Chippewa	38,520	LOW	1	0.06	2,800	157	3,335
Clare	30,926	LOW	1	0.06	5,000	280	1,382
Clinton	75,382	MEDIUM		0.00		0	8,700
Crawford	14,074	LOW	1	0.06		0	3,500
Delta	37,069	LOW		0.00		0	1,849
Dickinson	26,168	LOW	3	0.17	171,000	9,591	2,761
Eaton	107,759	MEDIUM		0.00		0	9,981
Emmet	32,694	LOW	1	0.06	4,000	224	4,933
Genesee	425,790	MEDIUM	14	0.79	220,500	12,367	42,022
Gladwin	25,692	LOW	1	0.06		0	1,550
Gogebic	16,427	LOW	2	0.11		0	1,429
Gd. Traverse	86,986	LOW	6	0.34	170,000	9,534	3,180
Gratiot	42,476	MEDIUM		0.00		0	6,536
Hillsdale	46,688	MEDIUM	1	0.06		0	14,986
Houghton	36,628	LOW	2	0.11	25,000	1,402	1,304
Huron	33,118	MEDIUM	3	0.17	535,000	30,006	19,775

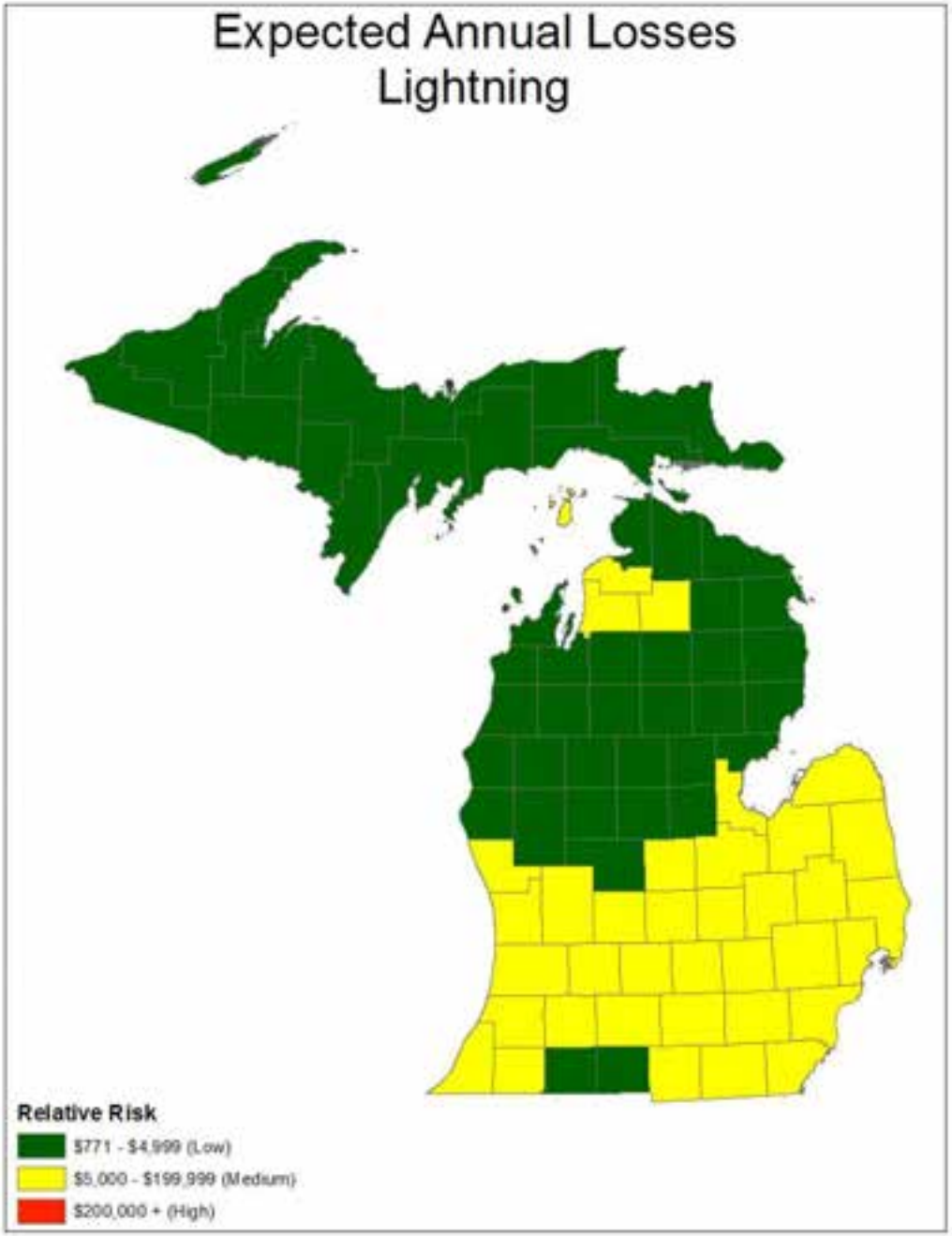
Loss Estimation for the State of Michigan: Lightning – cont.

COUNTY	Population *	Relative Risk	Number of Damaging Lightning Events: 1996-2013 (NCDC)	Expected Annual Events	Historic Lightning Damage ($) (NCDC)	Expected Annual Losses ($)	Expected Annual Losses ($)- Smoothed Data
Ingham	280,895	MEDIUM		0.00		0	20,772
Ionia	63,905	MEDIUM	1	0.06		0	5,467
Iosco	25,887	LOW	3	0.17	15,000	841	1,052
Iron	11,817	LOW	1	0.06	50,000	2,804	1,789
Isabella	70,311	LOW	1	0.06	10,000	561	2,587
Jackson	160,248	MEDIUM		0.00		0	25,720
Kalamazoo	250,331	MEDIUM	3	0.17	20,000	1,122	6,003
Kalkaska	17,153	LOW	2	0.11		0	3,324
Kent	602,622	MEDIUM	3	0.17	1,000,000	56,085	10,135
Keweenaw	2,156	LOW		0.00		0	771
Lake	11,539	LOW		0.00		0	2,054
Lapeer	88,319	MEDIUM	9	0.50	1,328,000	74,481	54,567
Leelanau	21,708	LOW	2	0.11	40,000	2,243	2,774
Lenawee	99,892	MEDIUM	18	1.01	880,000	49,355	36,416
Livingston	180,967	MEDIUM	12	0.67	1,844,000	103,421	45,937
Luce	6,631	LOW	1	0.06	70,000	3,926	2,744
Mackinac	11,113	LOW	1	0.06	150,000	8,413	3,674
Macomb	840,978	MEDIUM	25	1.40	2,927,000	164,162	74,869
Manistee	24,733	LOW	1	0.06		0	1,559
Marquette	67,077	LOW	4	0.22	41,000	2,299	2,054
Mason	28,705	LOW		0.00		0	2,550
Mecosta	42,798	LOW	2	0.11	50,000	2,804	3,053
Menominee	24,029	LOW		0.00		0	2,301
Midland	83,629	LOW	6	0.34	70,000	3,926	3,030
Missaukee	14,849	LOW	3	0.17	1,000	56	2,180
Monroe	152,021	MEDIUM	8	0.45	143,000	8,020	56,813
Montcalm	63,342	LOW	1	0.06		0	4,950
Montmorency	9,765	LOW		0.00		0	2,929
Muskegon	172,188	MEDIUM	1	0.06	40,000	2,243	9,257
Newaygo	48,460	LOW	1	0.06	100,000	5,609	4,850
Oakland	1,202,362	MEDIUM	39	2.19	2,318,000	130,006	67,761

Loss Estimation for the State of Michigan: Lightning – cont.

COUNTY	Population*	Relative Risk	Number of Damaging Lightning Events: 1996-2013 (NCDC)	Expected Annual Events	Historic Lightning Damage ($) (NCDC)	Expected Annual Losses ($)	Expected Annual Losses ($)-Smoothed Data
Oceana	26,570	LOW		0.00		0	4,924
Ogemaw	21,699	LOW	1	0.06		0	1,387
Ontonagon	6,780	LOW		0.00		0	1,282
Osceola	23,528	LOW		0.00		0	2,007
Oscoda	8,640	LOW	2	0.11		0	1,947
Otsego	24,164	MEDIUM	4	0.22	503,000	28,211	5,285
Ottawa	263,801	MEDIUM	3	0.17	60,000	3,365	12,315
Presque Isle	13,376	LOW	2	0.11	4,000	224	2,782
Roscommon	24,449	LOW	2	0.11	55,000	3,085	2,316
Saginaw	200,169	MEDIUM	7	0.39	202,500	11,357	15,461
St. Clair	163,040	MEDIUM	6	0.34	28,000	1,570	55,739
St. Joseph	61,295	LOW	5	0.28	30,000	1,683	4,633
Sanilac	43,114	MEDIUM	5	0.28	145,000	8,132	35,606
Schoolcraft	8,485	LOW		0.00		0	2,002
Shiawassee	70,648	MEDIUM	6	0.34	225,000	12,619	21,886
Tuscola	55,729	MEDIUM	1	0.06	100,000	5,609	25,294
Van Buren	76,258	MEDIUM	2	0.11	200,000	11,217	9,682
Washtenaw	344,791	MEDIUM	20	1.12	1,820,000	102,075	56,990
Wayne	1,820,584	MEDIUM	20	1.12	557,000	31,239	72,781
Wexford	32,735	LOW	1	0.06		0	2,086
MI TOTAL	9,883,640		291	16.32	17,229,300	966,310	

Notes: *2010 Census


Expected Annual Losses
Lightning
Relative Risk
$771 - $4,999 (Low)
$5,000 - $199,999 (Medium)
$200,000 + (High)

Loss Estimation for the State of Michigan: Snowstorms

COUNTY	Population*	Relative Risk	Number of Snowstorms: 1996-2013 (NCDC)	Expected Annual Events	Adjusted Historic Snowstorm Damage ($) NCDC	Expected Annual Losses ($)	Expected Annual Losses ($)- Smoothed Data
Alcona	10,942	MEDIUM	39	2.19	3,000	168	5,353
Alger	9,601	LOW	192	10.77	11,000	617	3,804
Allegan	111,408	MEDIUM	130	7.29	25,000	1,402	9,290
Alpena	29,598	MEDIUM	55	3.08	110,000	6,169	7,581
Antrim	23,580	MEDIUM	122	6.84	250,000	14,021	27,960
Arenac	15,899	LOW	38	2.13	0	0	2,109
Baraga	8,860	MEDIUM	118	6.62	6,000	0	8,678
Barry	59,173	MEDIUM	61	3.42	25,000	1,402	21,713
Bay	107,771	MEDIUM	46	2.58	25,000	1,402	8,493
Benzie	17,525	MEDIUM	79	4.43	2,600,000	0	108,824
Berrien	156,813	LOW	83	4.66	20,000	1,122	838
Branch	45,248	MEDIUM	40	2.24	0	0	27,687
Calhoun	136,146	MEDIUM	52	2.92	2,225,000	124,790	32,820
Cass	52,293	MEDIUM	72	4.04	0	0	8,016
Charlevoix	25,949	MEDIUM	110	6.17	295,000	16,545	13,291
Cheboygan	26,152	MEDIUM	71	3.98	206,000	11,554	11,057
Chippewa	38,520	LOW	98	5.50	85,000	4,767	2,710
Clare	30,926	MEDIUM	52	2.92	300,000	16,826	9,421
Clinton	75,382	MEDIUM	40	2.24	1,025,000	57,487	26,934
Crawford	14,074	MEDIUM	66	3.70	255,000	14,302	9,817
Delta	37,069	LOW	94	5.27	75,000	4,206	4,489
Dickinson	26,168	MEDIUM	68	3.81	20,000	1,122	8,308
Eaton	107,759	MEDIUM	45	2.52	1,025,000	57,487	34,280
Emmet	32,694	MEDIUM	91	5.10	204,000	11,441	13,270
Genesee	425,790	MEDIUM	49	2.75	1,650,000	92,541	24,639
Gladwin	25,692	MEDIUM	35	1.96	0	0	5,012
Gogebic	16,427	MEDIUM	167	9.37	63,000	3,533	10,039
Gd. Traverse	86,986	MEDIUM	93	5.22	5,612,000	0	72,682
Gratiot	42,476	MEDIUM	46	2.58	25,000	1,402	15,300
Hillsdale	46,688	MEDIUM	35	1.96	0	0	33,486
Houghton	36,628	MEDIUM	44	2.47	0	0	7,291
Huron	33,118	MEDIUM	54	3.03	1,500,000	84,128	23,798

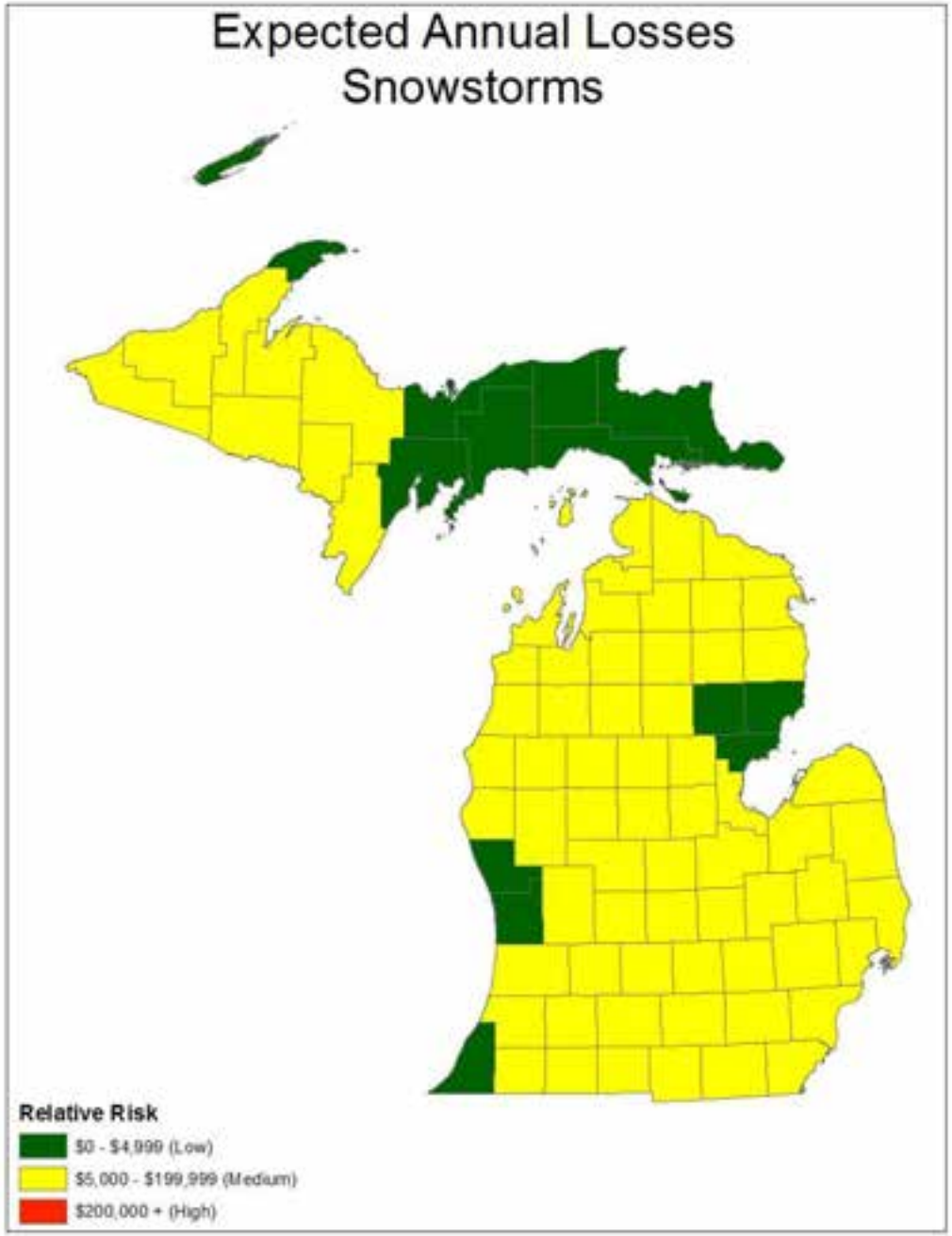
Loss Estimation for the State of Michigan: Snowstorms – cont.

COUNTY	Population *	Relative Risk	Number of Snowstorms: 1996-2013 (NCDC)	Expected Annual Events	Adjusted Historic Snowstorm Damage ($) NCDC	Expected Annual Losses ($)	Expected Annual Losses ($)- Smoothed Data
Ingham	280,895	MEDIUM	46	2.58	1,025,000	57,487	38,639
Ionia	63,905	MEDIUM	46	2.58	25,000	1,402	20,910
Iosco	25,887	LOW	42	2.36	0	0	3,155
Iron	11,817	MEDIUM	66	3.70	605,000	33,932	9,947
Isabella	70,311	MEDIUM	49	2.75	290,000	16,265	9,366
Jackson	160,248	MEDIUM	47	2.64	1,200,000	67,302	37,607
Kalamazoo	250,331	MEDIUM	73	4.09	25,000	1,402	15,876
Kalkaska	17,153	MEDIUM	106	5.95	290,000	16,265	23,537
Kent	602,622	MEDIUM	87	4.88	50,000	2,804	9,609
Keweenaw	2,156	LOW	160	8.97	0	0	3,483
Lake	11,539	MEDIUM	71	3.98	375,000	21,032	10,058
Lapeer	88,319	MEDIUM	46	2.58	10,000	561	18,392
Leelanau	21,708	MEDIUM	102	5.72	13,653,000	765,732	173,576
Lenawee	99,892	MEDIUM	42	2.36	505,000	28,323	32,545
Livingston	180,967	MEDIUM	47	2.64	129,000	7,235	32,566
Luce	6,631	LOW	119	6.67	3,500	196	2,728
Mackinac	11,113	LOW	58	3.25	50,000	2,804	4,367
Macomb	840,978	MEDIUM	43	2.41	170,000	9,534	17,572
Manistee	24,733	MEDIUM	72	4.04	350,000	19,630	51,398
Marquette	67,077	MEDIUM	154	8.64	262,000	14,694	7,616
Mason	28,705	MEDIUM	99	5.55	0	0	7,968
Mecosta	42,798	MEDIUM	56	3.14	40,000	2,243	10,347
Menominee	24,029	MEDIUM	71	3.98	7,000	393	7,368
Midland	83,629	MEDIUM	45	2.52	0	0	7,436
Missaukee	14,849	MEDIUM	63	3.53	185,000	10,376	23,127
Monroe	152,021	MEDIUM	33	1.85	45,000	2,524	23,606
Montcalm	63,342	MEDIUM	58	3.25	30,000	1,683	11,753
Montmorency	9,765	MEDIUM	48	2.69	165,000	9,254	9,190
Muskegon	172,188	LOW	102	5.72	0	0	4,425
Newaygo	48,460	MEDIUM	69	3.87	25,000	1,402	8,258
Oakland	1,202,362	MEDIUM	49	2.75	400,000	22,434	23,911

Loss Estimation for the State of Michigan: Snowstorms – cont.

COUNTY	Population*	Relative Risk	Number of Snowstorms: 1996-2013 (NCDC)	Expected Annual Events	Adjusted Historic Snowstorm Damage ($) NCDC	Expected Annual Losses ($)	Expected Annual Losses ($)- Smoothed Data
Oceana	26,570	MEDIUM	100	5.61	0	0	6,812
Ogemaw	21,699	LOW	45	2.52	50,000	2,804	4,860
Ontonagon	6,780	MEDIUM	200	11.22	16,000	897	9,271
Osceola	23,528	MEDIUM	56	3.14	510,000	28,603	11,074
Oscoda	8,640	MEDIUM	46	2.58	100,000	5,609	7,097
Otsego	24,164	MEDIUM	101	5.66	337,000	18,901	11,384
Ottawa	263,801	LOW	122	6.84	250,000	14,021	3,739
Presque Isle	13,376	MEDIUM	55	3.08	258,000	14,470	9,922
Roscommon	24,449	MEDIUM	52	2.92	100,000	0	8,201
Saginaw	200,169	MEDIUM	48	2.69	25,000	1,402	14,923
St. Clair	163,040	MEDIUM	57	3.20	45,000	2,524	14,193
St. Joseph	61,295	MEDIUM	42	2.36	0	0	16,004
Sanilac	43,114	MEDIUM	59	3.31	5,000	280	18,577
Schoolcraft	8,485	LOW	19	1.07	0	0	3,006
Shiawassee	70,648	MEDIUM	39	2.19	10,000	561	25,242
Tuscola	55,729	MEDIUM	46	2.58	0	0	17,407
Van Buren	76,258	MEDIUM	111	6.23	25,000	1,402	7,303
Washtenaw	344,791	MEDIUM	45	2.52	225,000	12,619	29,199
Wayne	1,820,584	MEDIUM	38	2.13	960,000	53,842	23,689
Wexford	32,735	MEDIUM	57	3.20	283,000	15,872	42,256
MI TOTAL	9,883,640		6,261	351.15	40,798,500	2,288,194	

Notes: *2010 Census


Expected Annual Losses
Snowstorms
Relative Risk
$0 - $4,999 (Low)
$5,000 - $199,999 (Medium)
$200,000 + (High)

Loss Estimation for the State of Michigan: Ice/Sleet Storms

COUNTY	Population*	Relative Risk	Number of Ice/Sleet Storms: 1996-2013 (NCDC)	Average Number of Ice/Sleet Storms per Year	Adjusted Historic Ice/Sleet Storms Damage ($) NCDC	Expected Annual Losses ($)	Expected Annual Losses ($)- Smoothed Data
Alcona	10,942	LOW	3	0.17	0	0	532
Alger	9,601	LOW	4	0.22	0	0	0
Allegan	111,408	MEDIUM	6	0.34	0	0	12,304
Alpena	29,598	LOW	2	0.11	0	0	171
Antrim	23,580	LOW	3	0.17	0	0	5
Arenac	15,899	LOW	2	0.11	50,000	2,804	4,125
Baraga	8,860	LOW	3	0.17	0	0	0
Barry	59,173	MEDIUM	6	0.34	25,000	1,402	12,983
Bay	107,771	MEDIUM	11	0.62	0	0	13,331
Benzie	17,525	LOW	4	0.22	0	0	1,666
Berrien	156,813	LOW	9	0.50	30,000	1,683	1,832
Branch	45,248	MEDIUM	9	0.50	0	0	7,492
Calhoun	136,146	MEDIUM	6	0.34	30,000	1,683	15,739
Cass	52,293	LOW	9	0.50	30,000	1,683	1,756
Charlevoix	25,949	LOW	3	0.17	0	0	0
Cheboygan	26,152	LOW	4	0.22	0	0	0
Chippewa	38,520	LOW	3	0.17	0	0	0
Clare	30,926	MEDIUM	4	0.22	355,000	19,910	12,691
Clinton	75,382	MEDIUM	7	0.39	330,000	18,508	26,861
Crawford	14,074	LOW	1	0.06	0	0	1,128
Delta	37,069	LOW	4	0.22	0	0	0
Dickinson	26,168	LOW	5	0.28	0	0	0
Eaton	107,759	MEDIUM	7	0.39	325,000	18,228	24,753
Emmet	32,694	LOW	4	0.22	0	0	0
Genesee	425,790	HIGH	8	0.45	110,000	6,169	652,904
Gladwin	25,692	MEDIUM	3	0.17	60,000	3,365	9,883
Gogebic	16,427	LOW	3	0.17	0	0	0
Gd. Traverse	86,986	LOW	4	0.22	0	0	1,751
Gratiot	42,476	MEDIUM	7	0.39	1,255,000	70,387	26,292
Hillsdale	46,688	MEDIUM	9	0.50	0	0	42,961
Houghton	36,628	LOW	1	0.06	0	0	0
Huron	33,118	MEDIUM	8	0.45	25,000	1,402	48,594

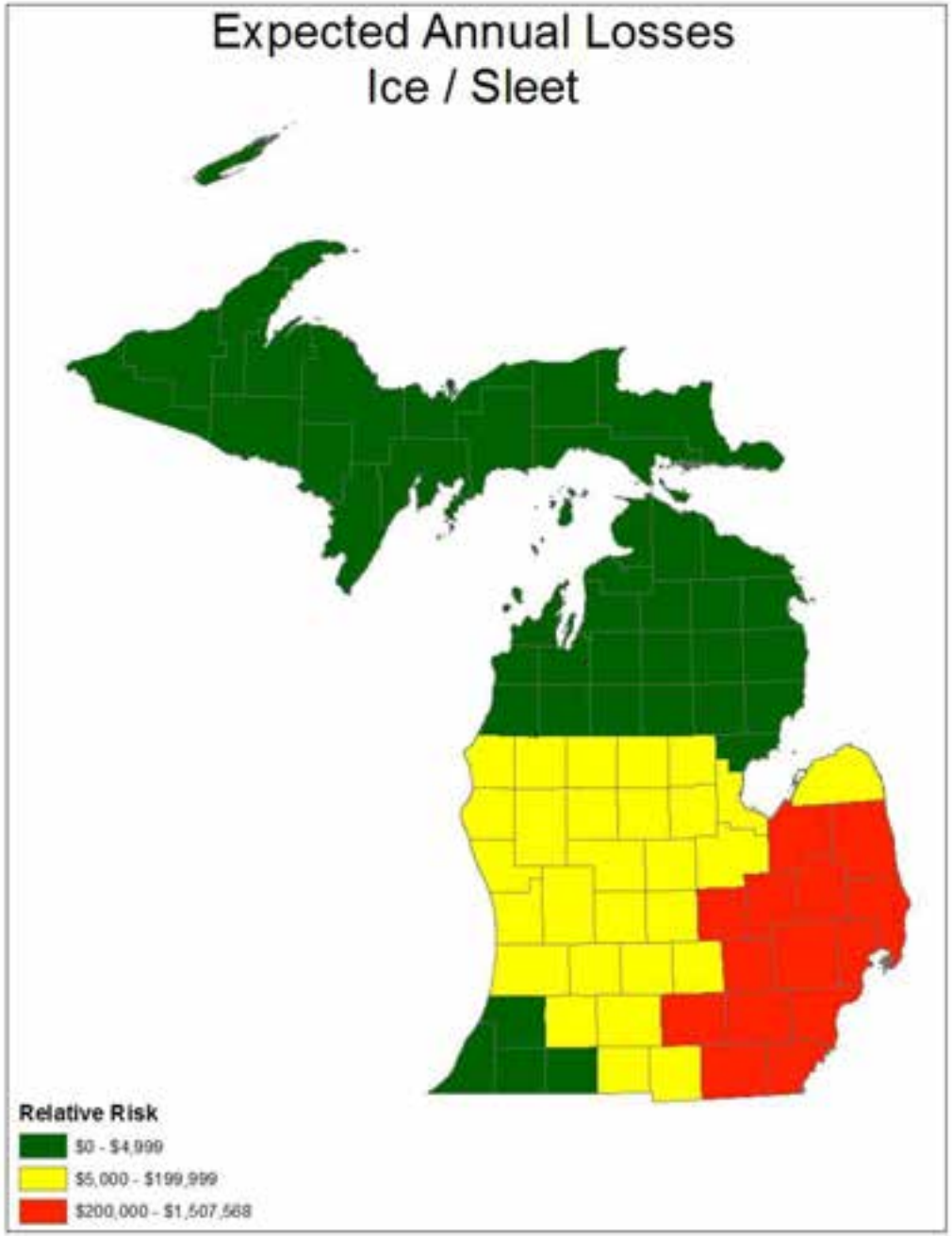
Loss Estimation for the State of Michigan: Ice/Sleet Storms – cont.

COUNTY	Population *	Relative Risk	Number of Ice/Sleet Storms: 1996-2013 (NCDC)	Expected Annual Events	Adjusted Historic Ice/Sleet Storms Damage ($) NCDC	Expected Annual Losses ($)	Expected Annual Losses ($)- Smoothed Data
Ingham	280,895	MEDIUM	7	0.39	340,000	19,069	176,164
Ionia	63,905	MEDIUM	8	0.45	330,000	18,508	20,780
Iosco	25,887	LOW	4	0.22	50,000	2,804	1,008
Iron	11,817	LOW	3	0.17	0	0	0
Isabella	70,311	MEDIUM	8	0.45	355,000	19,910	18,190
Jackson	160,248	HIGH	6	0.34	30,000	1,683	265,229
Kalamazoo	250,331	MEDIUM	6	0.34	75,000	4,206	5,226
Kalkaska	17,153	LOW	4	0.22	0	0	1,656
Kent	602,622	MEDIUM	8	0.45	1,000,000	56,085	20,668
Keweenaw	2,156	LOW	2	0.11	0	0	0
Lake	11,539	MEDIUM	1	0.06	200,000	11,217	10,235
Lapeer	88,319	HIGH	8	0.45	1,075,000	60,292	947,030
Leelanau	21,708	LOW	4	0.22	0	0	0
Lenawee	99,892	HIGH	8	0.45	2,530,000	141,896	281,235
Livingston	180,967	HIGH	7	0.39	2,310,000	129,557	606,228
Luce	6,631	LOW	5	0.28	0	0	0
Mackinac	11,113	LOW	3	0.17	0	0	0
Macomb	840,978	HIGH	8	0.45	54,325,000	3,046,831	1,507,568
Manistee	24,733	LOW	4	0.22	0	0	4,158
Marquette	67,077	LOW	4	0.22	0	0	0
Mason	28,705	MEDIUM	1	0.06	200,000	11,217	9,368
Mecosta	42,798	MEDIUM	8	0.45	355,000	19,910	16,916
Menominee	24,029	LOW	4	0.22	0	0	0
Midland	83,629	MEDIUM	11	0.62	0	0	16,671
Missaukee	14,849	LOW	2	0.11	0	0	4,723
Monroe	152,021	HIGH	8	0.45	4,540,000	254,627	810,108
Montcalm	63,342	MEDIUM	8	0.45	200,000	11,217	21,955
Montmorency	9,765	LOW	3	0.17	0	0	111
Muskegon	172,188	MEDIUM	6	0.34	200,000	11,217	17,769
Newaygo	48,460	MEDIUM	2	0.11	200,000	11,217	15,588
Oakland	1,202,362	HIGH	8	0.45	104,452,000	5,858,216	1,336,891

Loss Estimation for the State of Michigan: Ice/Sleet Storms – cont.

COUNTY	Population*	Relative Risk	Number of Ice/Sleet Storms: 1996-2013 (NCDC)	Expected Annual Events	Adjusted Historic Ice/Sleet Storms Damage ($) NCDC	Expected Annual Losses ($)	Expected Annual Losses ($)- Smoothed Data
Oceana	26,570	MEDIUM	2	0.11	200,000	0	12,882
Ogemaw	21,699	LOW	3	0.17	5,000	280	1,725
Ontonagon	6,780	LOW	3	0.17	0	0	0
Osceola	23,528	MEDIUM	4	0.22	455,000	25,519	12,558
Oscoda	8,640	LOW	2	0.11	0	0	685
Otsego	24,164	LOW	3	0.17	0	0	47
Ottawa	263,801	MEDIUM	8	0.45	500,000	28,043	19,387
Presque Isle	13,376	LOW	4	0.22	0	0	0
Roscommon	24,449	LOW	3	0.17	0	0	3,377
Saginaw	200,169	MEDIUM	12	0.67	1,010,000	56,646	144,685
St. Clair	163,040	HIGH	8	0.45	10,100,000	566,461	1,092,605
St. Joseph	61,295	LOW	10	0.56	30,000	1,683	2,053
Sanilac	43,114	HIGH	7	0.39	30,000	1,683	485,513
Schoolcraft	8,485	LOW	4	0.22	0	0	0
Shiawassee	70,648	HIGH	8	0.45	0	0	271,367
Tuscola	55,729	HIGH	9	0.50	20,000	1,122	344,534
Van Buren	76,258	LOW	6	0.34	25,000	1,402	3,995
Washtenaw	344,791	HIGH	7	0.39	3,400,000	190,690	793,889
Wayne	1,820,584	HIGH	8	0.45	5,000,000	280,426	1,290,511
Wexford	32,735	LOW	3	0.17	0	0	4,669
MI TOTAL	9,883,640		294	16.49	196,167,000	11,002,075	

Notes: *2010 Census


Expected Annual Losses
Ice / Sleet
Relative Risk
$0 - $4,999
$5,000 - $199,999
$200,000 - $1,507,568

Loss Estimation for the State of Michigan: Wildfires

COUNTY	Population*	Relative Risk	Number of Wildfires: 1996-2013 (NCDC)	Expected Annual Events	Adjusted Historic Wildfires Damage ($) NCDC	Expected Annual Losses ($)	Expected Annual Losses ($)- Smoothed Data
Alcona	10,942	MEDIUM		0.00	0.00	0	10,745
Alger	9,601	MEDIUM		0.00	0.00	0	117,684
Allegan	111,408	LOW		0.00	0.00	0	0
Alpena	29,598	MEDIUM		0.00	0.00	0	8,353
Antrim	23,580	MEDIUM		0.00	0.00	0	9,857
Arenac	15,899	LOW		0.00	0.00	0	4,631
Baraga	8,860	MEDIUM	2	0.11	0.05	2,804	45,629
Barry	59,173	LOW		0.00	0.00	0	0
Bay	107,771	LOW		0.00	0.00	0	75
Benzie	17,525	LOW		0.00	0.00	0	351
Berrien	156,813	LOW		0.00	0.00	0	0
Branch	45,248	LOW		0.00	0.00	0	0
Calhoun	136,146	LOW		0.00	0.00	0	0
Cass	52,293	LOW		0.00	0.00	0	0
Charlevoix	25,949	MEDIUM		0.00	0.00	0	6,403
Cheboygan	26,152	MEDIUM		0.00	0.00	0	23,775
Chippewa	38,520	MEDIUM		0.00	0.00	0	165,065
Clare	30,926	LOW		0.00	0.00	0	3,505
Clinton	75,382	LOW		0.00	0.00	0	0
Crawford	14,074	MEDIUM	2	0.11	1.58	88,334	14,543
Delta	37,069	MEDIUM		0.00	0.00	0	107,516
Dickinson	26,168	MEDIUM		0.00	0.00	0	66,367
Eaton	107,759	LOW		0.00	0.00	0	0
Emmet	32,694	LOW		0.00	0.00	0	0
Genesee	425,790	LOW		0.00	0.00	0	46
Gladwin	25,692	LOW		0.00	0.00	0	4,013
Gogebic	16,427	MEDIUM		0.00	0.00	0	16,174
Gd. Traverse	86,986	MEDIUM		0.00	0.00	0	5,185
Gratiot	42,476	LOW		0.00	0.00	0	0
Hillsdale	46,688	LOW		0.00	0.00	0	0
Houghton	36,628	MEDIUM		0.00	0.00	0	26,799
Huron	33,118	LOW		0.00	25,000	1,402	0

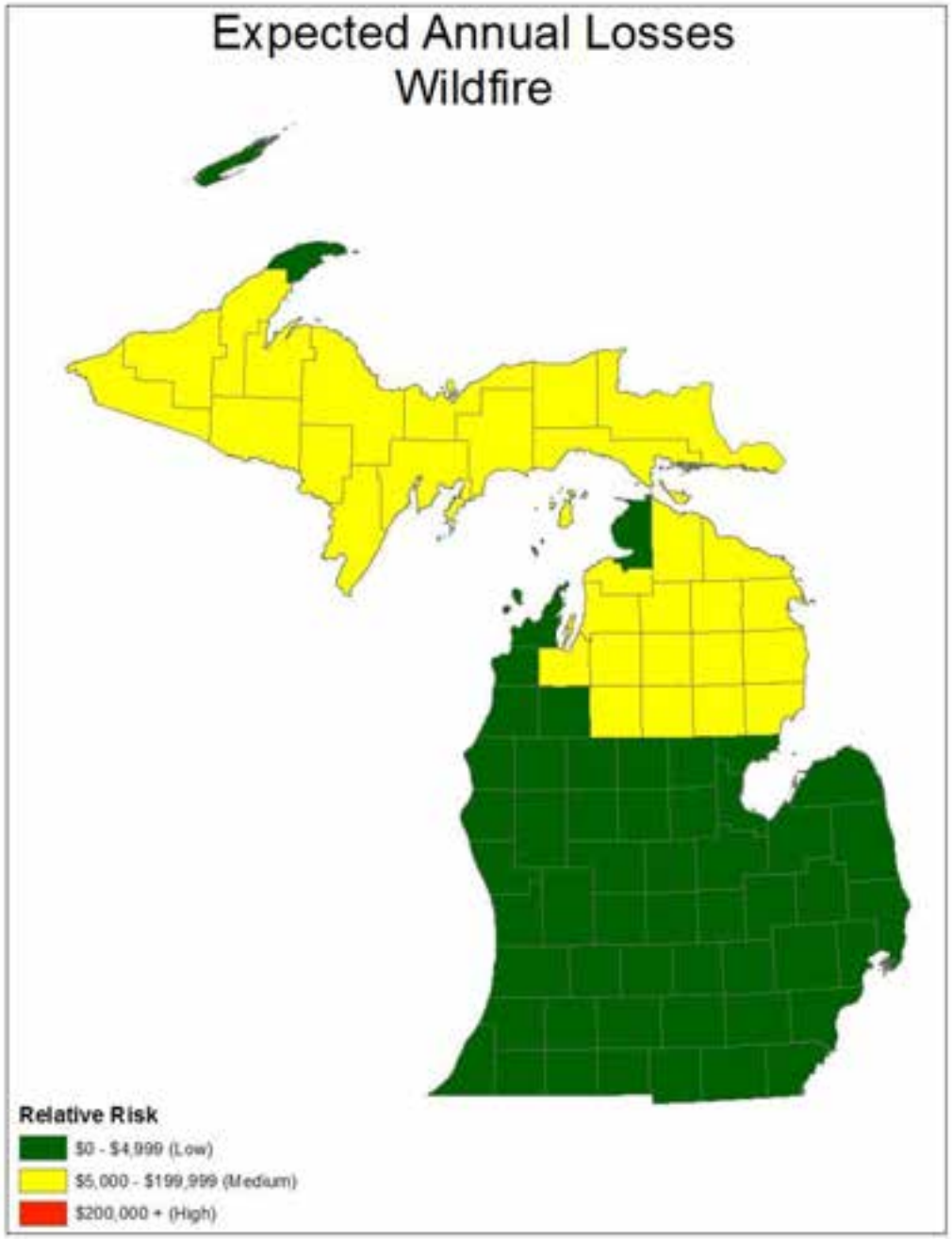
Loss Estimation for the State of Michigan: Wildfires – cont.

COUNTY	Population*	Relative Risk	Number of Wildfires: 1996-2013 (NCDC)	Expected Annual Events	Adjusted Historic Wildfires Damage ($) NCDC	Expected Annual Losses ($)	Expected Annual Losses ($)- Smoothed Data
Ingham	280,895	LOW		0.00	0.00	0	0
Ionia	63,905	LOW		0.00	0.00	0	0
Iosco	25,887	MEDIUM	1	0.06	0.04	2,243	8,588
Iron	11,817	MEDIUM		0.00	0.00	0	38,104
Isabella	70,311	LOW		0.00	0.00	0	0
Jackson	160,248	LOW		0.00	0.00	0	0
Kalamazoo	250,331	LOW		0.00	0.00	0	0
Kalkaska	17,153	MEDIUM	1	0.06	0.13	7,011	11,008
Kent	602,622	LOW		0.00	0.00	0	0
Keweenaw	2,156	LOW		0.00	0.00	0	280
Lake	11,539	LOW		0.00	0.00	0	110
Lapeer	88,319	LOW		0.00	0.00	0	118
Leelanau	21,708	LOW		0.00	0.00	0	292
Lenawee	99,892	LOW		0.00	0.00	0	0
Livingston	180,967	LOW		0.00	0.00	0	23
Luce	6,631	MEDIUM	2	0.11	12.04	675,266	166,534
Mackinac	11,113	MEDIUM		0.00	0.00	0	126,050
Macomb	840,978	LOW	2	0.11	0.02	1,122	210
Manistee	24,733	LOW		0.00	0.00	0	292
Marquette	67,077	MEDIUM	7	0.39	6.01	336,848	88,596
Mason	28,705	LOW		0.00	0.00	0	0
Mecosta	42,798	LOW		0.00	0.00	0	0
Menominee	24,029	MEDIUM		0.00	0.00	0	71,079
Midland	83,629	LOW		0.00	0.00	0	0
Missaukee	14,849	MEDIUM		0.00	0.00	0	7,006
Monroe	152,021	LOW		0.00	0.00	0	56
Montcalm	63,342	LOW		0.00	0.00	0	0
Montmorency	9,765	MEDIUM		0.00	0.00	0	9,028
Muskegon	172,188	LOW		0.00	0.00	0	0
Newaygo	48,460	LOW		0.00	0.00	0	0
Oakland	1,202,362	LOW		0.00	0.00	0	110

Loss Estimation for the State of Michigan: Wildfires – cont.

COUNTY	Population*	Relative Risk	Number of Wildfires: 1996-2013 (NCDC)	Expected Annual Events	Adjusted Historic Wildfires Damage ($) NCDC	Expected Annual Losses ($)	Expected Annual Losses ($)- Smoothed Data
Oceana	26,570	LOW		0.00	0.00	0	0
Ogemaw	21,699	MEDIUM		0.00	0.00	0	9,175
Ontonagon	6,780	MEDIUM	1	0.06	0.00	0	12,271
Osceola	23,528	LOW		0.00	0.00	0	1,599
Oscoda	8,640	MEDIUM	2	0.11	0.60	33,651	12,339
Otsego	24,164	MEDIUM		0.00	0.00	0	10,915
Ottawa	263,801	LOW		0.00	0.00	0	0
Presque Isle	13,376	MEDIUM		0.00	0.00	0	5,495
Roscommon	24,449	MEDIUM	1	0.06	0.00	0	10,453
Saginaw	200,169	LOW		0.00	0.00	0	0
St. Clair	163,040	LOW		0.00	0.00	0	166
St. Joseph	61,295	LOW		0.00	0.00	0	0
Sanilac	43,114	LOW		0.00	0.00	0	88
Schoolcraft	8,485	MEDIUM		0.00	0.00	0	134,990
Shiawassee	70,648	LOW		0.00	0.00	0	0
Tuscola	55,729	LOW	1	0.06	0.00	0	23
Van Buren	76,258	LOW		0.00	0.00	0	0
Washtenaw	344,791	LOW		0.00	0.00	0	55
Wayne	1,820,584	LOW		0.00	0.00	0	122
Wexford	32,735	LOW		0.00	0.00	0	3,199
MI TOTAL	9,883,640		23	1.29	20.46	1,147,280	

Notes: *2010 Census


Expected Annual Losses
Wildfire
Relative Risk
$0 - $4,999 (Low)
$5,000 - $199,999 (Medium)
$200,000 + (High)

Extreme Cold Temperatures for the State of Michigan: Risk / Probability of Occurrence

COUNTY	Population*	Relative Risk	Date of Record Cold Temperature	Record Cold Temperature °F	Number of Days Annually < 0° F**	Probability of Occurrence (%)
Alcona	10,942	MEDIUM	12/28/1977	-28	13.4	3.7
Alger	9,601	HIGH	7/7/1936	-33	20.7	5.7
Allegan	111,408	LOW	2/10/1912	-29	9.6	2.6
Alpena	29,598	HIGH	2/17/1979	-37	19.6	5.4
Antrim	23,580	HIGH	2/17/1979	-41	19	5.2
Arenac	15,899	MEDIUM	2/1/1994	-28	18.8	5.1
Baraga	8,860	HIGH	2/17/1979	-40	38.4	10.5
Barry	59,173	MEDIUM	1/4/1896	-40	11.7	3.2
Bay	107,771	LOW	1/19/1994	-18	6.7	1.8
Benzie	17,525	LOW	2/11/1889	-32	3.6	1.0
Berrien	156,813	LOW	1/12/1918	-21	4.7	1.3
Branch	45,248	MEDIUM	1/4/1981	-23	10	2.7
Calhoun	136,146	LOW	2/12/1899	-24	8.3	2.3
Cass	52,293	LOW	2/7/1978	-23	8.9	2.4
Charlevoix	25,949	MEDIUM	2/17/1979	-35	18.4	5.0
Cheboygan	26,152	HIGH	2/9/1934	-35	20.9	5.7
Chippewa	38,520	HIGH	2/8/1934	-37	31.7	8.7
Clare	30,926	HIGH	2/20/1929	-39	21.6	5.9
Clinton	75,382	LOW	2/2/1895	-42	9.4	2.6
Crawford	14,074	HIGH	2/17/1979	-42	30.6	8.4
Delta	37,069	HIGH	2/17/1979	-30	22.9	6.3
Dickinson	26,168	HIGH	2/3/1996	-45	37.7	10.3
Eaton	107,759	MEDIUM	2/10/1912	-31	13.5	3.7
Emmet	32,694	MEDIUM	2/9/1934	-35	10.7	2.9
Genesee	425,790	MEDIUM	2/14/1916	-28	10.5	2.9
Gladwin	25,692	MEDIUM	2/20/1929	-39	18.9	5.2
Gogebic	16,427	HIGH	1/17/1982	-41	44.3	12.1
Gd Traverse	86,986	MEDIUM	2/17/1979	-37	11	3.0
Gratiot	42,476	MEDIUM	2/5/1918	-29	10.1	2.8
Hillsdale	46,688	MEDIUM	2/11/1912	-25	12.6	3.4
Houghton	36,628	MEDIUM	2/4/1996	-28	18	4.9
Huron	33,118	LOW	1/30/1951	-23	9.4	2.6
Ingham	280,895	MEDIUM	1/4/1981	-29	13.1	3.6
Ionia	63,905	MEDIUM	1/15/1963	-25	10.4	2.8
Iosco	25,887	MEDIUM	4/7/1904	-34	16.3	4.5
Iron	11,817	HIGH	2/17/1979	-42	55.1	15.1
Isabella	70,311	LOW	2/5/1918	-30	9.9	2.7
Jackson	160,248	LOW	2/10/1912	-21	9.4	2.6
Kalamazoo	250,331	LOW	2/10/1912	-22	5.3	1.5
Kalkaska	17,153	HIGH	2/4/1996	-34	21	5.7
Kent	602,622	LOW	2/13/1899	-24	7.9	2.2
Keweenaw	2,156	MEDIUM	3/6/2003	-23	13.4	3.7
Lake	11,539	HIGH	2/11/1999	-49	21.3	5.8

Extreme Cold Temperatures for the State of Michigan: Risk / Probability of Occurrence – cont.

COUNTY	Population*	Relative Risk	Date of Record Cold Temperature	Record Cold Temperature °F	Number of Days Annually < 0° F**	Probability of Occurrence (%)
Lapeer	88,319	MEDIUM	1/11/1984	-26	11.5	3.1
Leelanau	21,708	LOW	2/17/1979	-24	8.5	2.3
Lenawee	99,892	MEDIUM	1/20/1992	-26	10.2	2.8
Livingston	180,967	MEDIUM	1/19/1994	-23	11.3	3.1
Luce	6,631	HIGH	2/7/1899	-32	24.5	6.7
Mackinac	11,113	MEDIUM	2/16/1987	-29	13.9	3.8
Macomb	840,978	LOW	2/10/1912	-24	3.6	1.0
Manistee	24,733	LOW	2/11/1899	-38	4.6	1.3
Marquette	67,077	HIGH	2/17/1979	-34	35.2	9.6
Mason	28,705	LOW	2/11/1899	-38	5.6	1.5
Mecosta	42,798	MEDIUM	2/11/1899	-36	15.7	4.3
Menominee	24,029	HIGH	2/3/1996	-45	36.3	9.9
Midland	83,629	LOW	1/19/1994	-19	7.6	2.1
Missaukee	14,849	HIGH	1/30/1951	-37	24.5	6.7
Monroe	152,021	LOW	2/5/1918	-21	5	1.4
Montcalm	63,342	MEDIUM	1/19/1994	-26	11.5	3.1
Montmorency	9,765	HIGH	2/9/1934	-46	25.2	6.9
Muskegon	172,188	LOW	2/11/1899	-30	4.1	1.1
Newaygo	48,460	MEDIUM	2/1/1918	-37	13.2	3.6
Oakland	1,202,362	LOW	2/5/1918	-22	6	1.6
Oceana	26,570	LOW	2/11/1899	-35	7.3	2.0
Ogemaw	21,699	HIGH	2/10/1912	-36	23.1	6.3
Ontonagon	6,780	HIGH	2/17/1979	-42	28	7.7
Osceola	23,528	HIGH	1/15/1963	-30	24.2	6.6
Oscoda	8,640	HIGH	2/1/1918	-47	24.8	6.8
Otsego	24,164	MEDIUM	2/9/1934	-51	19.7	5.4
Ottawa	263,801	LOW	2/22/1936	-18	2.3	0.6
Presque Isle	13,376	MEDIUM	2/18/1979	-37	15.4	4.2
Roscommon	24,449	HIGH	3/3/1943	-43	20.8	5.7
Saginaw	200,169	LOW	2/5/1918	-23	7.6	2.1
Sanilac	163,040	LOW	1/23/1949	-21	8.9	2.4
Schoolcraft	61,295	HIGH	1/20/1994	-23	25.4	7.0
Shiawassee	43,114	MEDIUM	2/23/1925	-31	11.6	3.2
St. Clair	8,485	LOW	2/4/1970	-33	5.3	1.5
St. Joseph	70,648	LOW	2/5/1918	-26	8.7	2.4
Tuscola	55,729	MEDIUM	2/9/1934	-30	12.8	3.5
Van Buren	76,258	LOW	2/11/1899	-22	2.6	0.7
Washtenaw	344,791	LOW	2/5/1918	-25	5.9	1.6
Wayne	1,820,584	LOW	2/20/1929	-24	2.3	0.6
Wexford	32,735	HIGH	1/30/1951	-43	22.9	6.3
AVERAGE:				**-31.6**	**15.7**	**4.2**

Notes: *2010 Census; **Days recorded from 1971-2001.

Extreme Hot Temperatures for the State of Michigan: Risk / Probability of Occurrence

COUNTY	Population*	Relative Risk	Date of Record Hot Temperature	Record Hot Temperature °F	Number of Days Annually > 90° F**	Probability of Occurrence (%)
Alcona	10,942	LOW	8/13/1918	107	3.8	1.0
Alger	9,601	LOW	7/7/1936	103	3.1	0.8
Allegan	111,408	HIGH	7/29/1916	106	9.6	2.6
Alpena	29,598	MEDIUM	7/13/1936	106	6.2	1.7
Antrim	23,580	MEDIUM	7/13/1936	103	6.3	1.7
Arenac	15,899	MEDIUM	6/20/1995	100	6.9	1.9
Baraga	8,860	LOW	6/27/1971	96	1.6	0.4
Barry	59,173	HIGH	7/14/1936	109	10.0	2.7
Bay	107,771	MEDIUM	6/20/1995	101	8.6	2.4
Benzie	17,525	LOW	8/19/1955	95	0.9	0.2
Berrien	156,813	HIGH	6/1/1934	104	11.9	3.3
Branch	45,248	MEDIUM	7/24/1934	108	8.5	2.3
Calhoun	136,146	HIGH	7/14/1936	104	9.2	2.5
Cass	52,293	HIGH	6/20/1953	103	12.7	3.5
Charlevoix	25,949	MEDIUM	8/18/1955	102	8.9	2.4
Cheboygan	26,152	LOW	8/6/1947	104	2.7	0.7
Chippewa	38,520	LOW	8/5/1947	98	1.3	0.4
Clare	30,926	HIGH	7/13/1936	105	10.9	3.0
Clinton	75,382	HIGH	8/6/1947	102	11.3	3.1
Crawford	14,074	MEDIUM	7/11/1936	104	6.6	1.8
Delta	37,069	LOW	8/21/1955	100	0.6	0.2
Dickinson	26,168	LOW	7/13/1936	104	1.9	0.5
Eaton	107,759	MEDIUM	7/14/1936	106	7.5	2.1
Emmet	32,694	LOW	8/21/1955	99	2.0	0.5
Genesee	425,790	MEDIUM	7/8/1936	108	7.3	2.0
Gladwin	25,692	HIGH	7/13/1936	105	10.9	3.0
Gogebic	16,427	LOW	7/13/1936	103	5.7	1.6
Gd Traverse	86,986	MEDIUM	7/7/1936	105	8.8	2.4
Gratiot	42,476	HIGH	7/14/1936	108	12.0	3.3
Hillsdale	46,688	MEDIUM	7/14/1936	107	7.4	2.0
Houghton	36,628	LOW	7/7/1988	102	2.3	0.6
Huron	33,118	MEDIUM	7/8/1936	103	7.0	1.9
Ingham	280,895	HIGH	7/6/1988	100	9.1	2.5
Ionia	63,905	HIGH	7/6/1988	103	12.8	3.5
Iosco	25,887	LOW	7/8/1936	106	4.3	1.2
Iron	11,817	LOW	6/30/1963	99	4.4	1.2
Isabella	70,311	MEDIUM	8/6/1918	108	8.8	2.4
Jackson	160,248	HIGH	7/14/1936	105	10.3	2.8
Kalamazoo	250,331	HIGH	7/13/1936	109	16.3	4.5
Kalkaska	17,153	LOW	7/15/1995	96	2.3	0.6
Kent	602,622	HIGH	6/20/1953	102	9.6	2.6
Keweenaw	2,156	LOW	7/7/1988	99	1.4	0.4
Lake	11,539	MEDIUM	7/13/1936	111	7.2	2.0

Extreme Hot Temperatures for the State of Michigan: Risk / Probability of Occurrence – cont.

COUNTY	Population*	Relative Risk	Date of Record Hot Temperature	Record Hot Temperature °F	Number of Days Annually > 90° F**	Probability of Occurrence (%)
Lapeer	88,319	MEDIUM	6/26/1988	100	8.8	2.4
Leelanau	21,708	MEDIUM	7/14/1995	102	7.2	2.0
Lenawee	99,892	HIGH	7/24/1934	108	11.7	3.2
Livingston	180,967	MEDIUM	7/24/1934	104	6.3	1.7
Luce	6,631	LOW	7/13/1936	103	1.2	0.3
Mackinac	11,113	LOW	8/4/1985	93	0.1	0.0
Macomb	840,978	MEDIUM	7/5/1911	106	8.6	2.4
Manistee	24,733	LOW	8/5/1947	100	3.3	0.9
Marquette	67,077	LOW	7/19/1977	104	3.8	1.0
Mason	28,705	LOW	8/2/1988	99	3.7	1.0
Mecosta	42,798	MEDIUM	7/30/1916	103	7.6	2.1
Menominee	24,029	LOW	7/26/1955	101	5.3	1.5
Midland	83,629	HIGH	7/5/1911	107	12.6	3.4
Missaukee	14,849	LOW	7/11/1936	106	4.1	1.1
Monroe	152,021	HIGH	6/26/1988	106	19.4	5.3
Montcalm	63,342	HIGH	7/13/1936	108	11.1	3.0
Montmorency	9,765	MEDIUM	7/13/1936	104	6.4	1.8
Muskegon	172,188	LOW	7/30/1913	99	2.1	0.6
Newaygo	48,460	MEDIUM	7/13/1936	111	5.2	1.4
Oakland	1,202,362	HIGH	7/5/1911	104	10.6	2.9
Oceana	26,570	LOW	7/4/1911	104	2.9	0.8
Ogemaw	21,699	MEDIUM	7/13/1936	107	6.5	1.8
Ontonagon	6,780	LOW	7/7/1988	101	4.5	1.2
Osceola	23,528	MEDIUM	8/21/1955	100	6.5	1.8
Oscoda	8,640	MEDIUM	7/13/1936	112	7.9	2.2
Otsego	24,164	LOW	7/1/2001	101	4.6	1.3
Ottawa	263,801	LOW	6/20/1953	100	1.9	0.5
Presque Isle	13,376	LOW	7/8/1988	100	4.2	1.1
Roscommon	24,449	LOW	6/19/1995	103	3.5	1.0
Saginaw	200,169	MEDIUM	7/13/1936	111	8.9	2.4
Sanilac	163,040	MEDIUM	7/15/1977	103	7.3	2.0
Schoolcraft	61,295	LOW	7/21/1934	107	.3	0.1
Shiawassee	43,114	MEDIUM	7/24/1934	105	8	2.2
St. Clair	8,485	HIGH	7/9/1936	103	10.2	2.8
St. Joseph	70,648	HIGH	9/18/1995	120	13.7	3.7
Tuscola	55,729	HIGH	7/13/1936	108	12.4	3.4
Van Buren	76,258	HIGH	7/5/1911	105	11.2	3.1
Washtenaw	344,791	HIGH	7/24/1934	107	9.7	2.7
Wayne	1,820,584	HIGH	7/20/1930	104	11.8	3.2
Wexford	32,735	LOW	7/13/1936	104	2.9	0.8
AVERAGE:				**103.9**	**7.0**	**1.91**

Notes: *2010 Census; **Days recorded from 1971-2001.

General Natural Hazard Vulnerability: Lifelines* (utility and transportation infrastructure)

LIFELINE	Component	Primary Ownership	Flood Vulnerability	Wind Vulnerability	Earthquake Vulnerability	Winter Storm Vulnerability (snow / ice)	Extreme Temperature Vulnerability (heat / cold)	Land Subsidence Vulnerability
Oil Products Systems:	Buried Pipelines	Private	●		●			●
	Above Ground Pipelines	Private	●		●			●
	Pumping Stations	Private	●		●			●
	Well Facilities	Private			●			
	Refineries	Private	●	●	●			
	Storage Tanks	Private	●	●	●			
Natural Gas Systems:	Buried Pipelines	Private	●		●			●
	Above Ground Pipelines	Private	●		●			●
	Compressor Stations	Private			●			●
	Well Facilities	Private			●			
	Liquid Natural Gas Storage	Private	●	●	●			●
Water Systems:	Buried Pipelines	Local	●		●		●	●
	Above Ground Pipelines	Local	●		●		●	●
	Pumping Stations	Local	●		●	●	●	●
	Treatment Plants	Local	●	●	●	●	●	●
	Storage Tanks	Local	●	●	●	●	●	●
Wastewater Systems:	Buried Pipelines	Local	●		●		●	●
	Above Ground Pipelines	Local	●		●		●	●
	Pumping Stations	Local	●		●	●	●	●
	Treatment Plants	Local	●	●	●	●	●	●
	Storage Basins	Local	●	●	●	●	●	●
Storm Drainage:	Buried Pipelines	Local	●		●		●	●
	Open Channels	Local	●		●	●	●	●
	Catch Basins / Outflows	Local	●		●	●		●
	Storage Basins	Private / Local	●		●	●	●	●
Electric Power Systems:	Substations	Private / Local	●	●	●	●		●
	Transmission Towers / Poles	Private / Local	●	●	●	●		●
	Distribution Poles	Private / Local	●	●	●	●		●
	Buried Cables	Private / Local	●	●	●	●		●

General Natural Hazard Vulnerability: Lifelines* (utility and transportation infrastructure) – cont.

LIFELINE	Component	Primary Ownership	Flood Vulnerability	Wind Vulnerability	Earthquake Vulnerability	Winter Storm Vulnerability (snow / ice)	Extreme Temperature Vulnerability (heat / cold)	Land Subsidence Vulnerability
Telecommunications:	Towers / Masts / Poles	Private	●	●	●	●		●
	Buried Cables	Private	●		●			●
	Underwater Cables	Private			●			
	Above Ground Cables	Private	●	●	●	●		●
	Switching Equipment	Private	●	●	●	●		●
Highways and Roads:	Bridges	Local / State	●		●	●		
	Embankments	Local / State	●		●	●		●
	Road Beds	Local / State	●		●	●	●	●
	Culverts	Local / State	●		●	●		●
	Tunnels	Local / State	●		●			●
	Signs / Signals	Local / State	●	●	●	●	●	●
Ports / Inland Waterways:	Breakwaters / Jetties	Local / State	●	●				
	Sea Walls	Local / State	●	●	●	●		
	Container Handling	Private	●	●		●		
	Cargo Movement Facilities	Private	●	●		●		
	Marine Oil Terminals	Private	●	●	●	●		
Railroads:	Bridges	Private	●		●	●		●
	Embankments	Private	●		●	●		●
	Rails / Ties / Ballast	Private	●		●	●	●	●
	Culverts	Private	●		●	●		●
	Signs / Signals	Private	●	●	●	●	●	●
Airports:	Terminal Buildings	Local	●	●	●	●		●
	Aircraft Hangars	Local / Private	●	●	●	●		●
	Runways / Taxiways	Local	●		●	●	●	●
	Lights / Signs / Signals	Local	●	●	●	●	●	●
	Access Roads / Parking Areas	Local	●		●	●	●	●

Notes: *Based on the American Lifelines Alliance 2003 and Michigan disaster events.

Loss Estimation Tables for State Critical Facilities

NOTE: Actual information about facility names, addresses, etc. are withheld from public versions of this document. They are only available for access to authorized persons.

INTRODUCTORY TEXT SECTIONS:
General Loss Estimation for Natural Hazards
Methods for Broadly Analyzing Impacts of Specific Natural Hazards
State Owned/Operated Critical Facility Loss Estimation for Location Specific Natural Hazards
State Owned/Operated Critical Facility Loss Estimation for Non-Location Specific Natural Hazards

LOSS ESTIMATION AND RELATED TABLES:
1. General Hazard Vulnerability of State Owned/Operated Critical Facilities Addressed in this Plan
2. State Owned/Operated Critical Facilities – Wildfires
3. State Owned/Operated Critical Facilities – Flooding
4. State Owned/Operated Critical Facilities – Land Subsidence
5. State Owned/Operated Critical Facilities – Earthquake
6. State Owned/Operated Critical Facilities – Dam Failure Area
7. General Natural Hazard Vulnerability: Lifelines (utility and transportation infrastructure)

State Owned/Operated Critical Facility Loss Estimation for Significant Natural Hazards

GENERAL METHODOLOGY

In late 2013, the Michigan Department of Technology, Management, and Budget had provided its latest list of state facilities for analysis in this plan. These included state owned facilities as well as leased facilities, thus constituting the best available list of state owned/operated facilities and infrastructure. This list was analyzed in its entirety during early 2014, using the following procedure. There were 538 facilities (26 more than had been analyzed in the previous plan), although 6 of these were located outside fo the state. The value of each facility was already provided by MDTMB for the list of state-owned facilities, but needed to be estimated for the list of state-leased facilities. Square-footage information was available for the list of state-leased facilities, and information about the type of facility use was available for the entire list. Using this information, along with the online RSMeans calculator which provided a per-square-foot value for each property type, the total values of each state-leased facility were calculated.

The available list of RSMeans building types had to be matched up with the closest corresponding state facilities use classifications. The following table shows what RSMeans categories were selected to represent the state facility use classifications:

State Facility Use Classification	Selected RSMeans Building Type Classification
Hospital	Hospital, 2-3 story
Laboratory	College laboratory
Mechanic Shop	Garage, repair
Mixed Use	Store, Department, 2-story
Office Building	Office, 2-4 story
Retail	Store, retail
Training	College, classroom
Warehouse	Warehouse
(Parking, Other)	(No structures; not assessed)

The categories were selected so that the averages for each facility type would represent the average characteristics of each classification type, between the two sources. For most facilities, state facility building data was plugged directly into the RSMeans tool to produce individual results. For the office building classification (the majority of state facilities), an average of $359 per square foot was used—a calculated representation of the central tendency in the RSMeans data, after testing several cases at both extremes of the floor area range across state facilities, so that variation in the square footage of structures at both ends of the range would approximately balance out across the hundreds of office facilities. The RSMeans results are based on 3rd quarter 2012 national average costs for that type of construction (not location-specific results). The values assume union wage labor and construction with no basements. RSMeans offers three estimation ranges— low, medium, and high, and the values chosen were always the medium result (including architectural fees, contractor overhead, and contractor profit). The result was considered to be an appropriate estimate of the replacement costs of current facilities.

Next, the list of facilities (in a spreadsheet) was sorted by location according to county. Although not included in public versions of this document, the facilities list includes lat/long, address, city, and county location information, which state department controls the facility, a classification and/or description of each facility's use, its square footage, and its total value. Added to this spreadsheet were columns representing the results of the county loss assessments in this Attachment and the main hazard analysis sections of this document. Cells of the spreadsheet were populated with formulas that took the annual expected damages from each significant natural hazard, in each county, and divided it by the total assessed property values within that county, to produce a ratio that represents the expected damages per unit-value of assessed property. The county property assessment information was obtained from http://www.michigan.gov/treasury/0,1607,7-121-1751_2228_21957_45818---,00.html, a Michigan Department of Treasury web site. In order to best match the kind of damage information reported in the NCDC records, all types of property (including building contents) were included in the collected assessment data. A ratio of the county's average annual damages by hazard, compared with the total assessed property value in that county, resulted in a value for each county that represented the average damage from each hazard per property valuation. This provided the necessarily link to estimate the expected losses to each state facility in

Michigan's numerous counties. The derived ratio, which was in effect an average percentage of property values in each county that is annually lost to each hazard, was applied as a factor to the full list of state facility property values, resulting in multiple columns that provide estimated annual losses to each facility, by hazard type. Note that the described factor does vary throughout the state, according to each facility's county of location. The results were considered far more sophisticated and valid than those obtained from methods used in any of the previous editions of this plan. By totaling all hazards for each facility, a combined estimate of damages from all significant natural hazards was also produced, and in addition, by totaling the columns for each hazard and all hazards' impacts within the spreadsheet, total expected annual losses for all state facilities, by hazard as well as in total, were also produced. (As explained under the county loss assessments, and for the same reasons, assessments were not made for Michigan's least-damaging natural hazards [as listed previously], because of a dearth of validly generalizable data and too-short of an historical time frame over which analytically usable data is currently available.)

GENERAL FINDINGS

The results of the loss estimation procedure for all facilities are presented in the following list:

1. State facility annual expected losses from flooding: $200,363
2. State facility annual expected losses from severe winds $114,793
3. State facility annual expected losses from tornadoes $106,577
4. State facility annual expected losses from hail $ 99,032
5. State facility annual expected losses from ice/sleet storms $ 43,915
6. State facility annual expected losses from snowstorms $ 8,401
7. State facility annual expected losses from wildfire $ 7,406
8. State facility annual expected losses from lightning $ 4,427

Total state facility annual expected losses from all significant natural hazards: $584,912. On their face, these values all seem quite realistic, although the flood hazard needed to be assessed in an additional manner, since the raw application of county-wide trends to a limited number of specific sites was considered less accurate for that hazard than the application of county-wide trends to the general weather hazards. The most significant hazards in each county, and the most at-risk counties for each hazard (as described previously) parallel the loss estimates for state facilities and infrastructure located in each county (or multi-county risk regions) in the state. But with flooding, there are specific floodplain locations identified, and these were able to be compared with state facility locations, using Geographic Information Systems, for the approximately one-half of the Michigan Counties for which digital Flood Insurance Rate Maps (dFIRMs) were available. (See the maps in the riverine flood section of the main body of this plan, for more details.) The resulting geographic analysis identified 11 state facilities that appeared to have some level of flood risk. Although only two facilities fell squarely within the floodplains, it was considered a bit more realistic to assess flood risks by slightly expanding the analytic routine to include an additional 200-foot search radius. (Topographic analysis was not a readily available mechanism to use for this procedure, although it should be considered as an additional factor in subsequent analyses for future editions of this plan. Given that dFIRM data was not yet available for the entire state, a more complex analysis of available data might have led to "false precision" when it comes to the full assessment of all facilities. In this sense, the $200,363 figure provided above might indeed be more reflective in certain ways of actual flood risks, since it is based upon as assessment of all counties in Michigan.)

As briefly described in the text box on page 641, this second method of flood analysis made use of information from a FEMA flood damage estimation table, using the category of less than ½ foot of surface flooding (2 or more feet in any basement) and the 2 story no basement category, to better translate the resilience of state facilities from the original weaker structures the FEMA table had been produced to represent (i.e. the inclusion and comparison of various residential structures, including mobile homes; whereas the durability of state facilities would be expected on average to be greater than such residences). The result was to use an estimated damage amount of 5% of replacement value per flood event. Because of the more significant value of structure contents in state facilities, however, than the FEMA residential baseline provided in the table, the estimated total losses were doubled, to 10% of the structure's replacement value. The probability of flooding was represented as 1% chance per year, following the typical definition of a floodplain. The result was to find that the 11 structures, which had a total value of $114,251,137, would have annual expected losses of $114,251 from the flood hazard. There may be additional facilities in the floodplains outside of those areas for which dFIRMs were available, however it does appear that both methods of analysis are corresponding with each other, and the estimated $200,000 annual loss estimate from flooding (found above) is likely to be accurate, after all.

NOTE: Publicly available versions of this document do not include pages 687-706, in order to preserve the confidentiality of certain information regarding Michigan's critical facilities so that it is not misused. This information may be examined by authorized personnel only.

Presidential Declarations in Michigan: 1953-2013*

Date of Incident	Type of Incident	Affected Area	Type of Declaration / Federal ID Number**
4/16/13-5/14/13	Flooding	16 counties: Allegan, Baraga, Barry, Gogebic, Houghton, Ionia, Kent, Keweenaw, Marquette, Midland, Muskegon, Newaygo, Ontonagon, Osceola, Ottawa, and Saginaw Co.	Major Disaster (4121)
7/14/ 08	Thunderstorms, flooding	12 counties: Allegan, Barry, Eaton, Ingham, Lake, Manistee, Mason, Missaukee, Osceola, Ottawa, Saginaw, and Wexford Co.	Major Disaster (1777)
9/07/05	Hurricane evacuation	All 83 counties	Emergency (3225)
5/20/04-6/8/04	Thunderstorms, flooding	23 counties: Barry, Berrien, Cass, Eaton, Genesee, Gladwin, Ingham, Ionia, Jackson, Kent, Livingston, Macomb, Mecosta, Muskegon, Oakland, Ottawa, Saginaw, Sanilac, Shiawassee, St. Clair, St. Joseph, Washtenaw, and Wayne Co.	Major Disaster (1527)
8/14-17/03	Electric power failure	14 counties: Calhoun, Eaton, Genesee, Hillsdale, Ingham, Kalamazoo, Lapeer, Livingston, Macomb, Monroe, Oakland, St. Clair, Washtenaw, and Wayne Co.	Emergency (3189)
4/10/02-5/9/02	Flooding	6 counties: Baraga, Gogebic, Houghton, Iron, Marquette, and Ontonagon Co.; plus the Keweenaw Bay Indian Community	Major Disaster (1413)
12/11-31/00	Blizzard, snowstorm	39 counties: Allegan, Barry, Bay, Berrien, Branch, Calhoun, Cass, Clare, Clinton, Eaton, Genesee, Gladwin, Gratiot, Hillsdale, Huron, Ingham, Ionia, Isabella, Jackson, Kalamazoo, Kent, Lapeer, Livingston, Macomb, Mecosta, Midland, Montcalm, Muskegon, Oakland, Osceola, Ottawa, Saginaw, St. Clair, St. Joseph, Sanilac, Shiawassee, Tuscola, Van Buren, and Washtenaw Co.	Emergency (3160)
9/10-11/00	Urban flooding	2 counties: Oakland and Wayne Co.	Major Disaster (1346)
5/2-10/99	Wildfire	2 counties: Marquette and Mackinac Co.; (Grant Recipient: Michigan Dept. of Natural Resources)	Fire Suppression
1/2-15/99	Blizzard, snowstorm	31 counties: Alcona, Allegan, Arenac, Barry, Berrien, Cass, Crawford, Ionia, Iosco, Jackson, Kalamazoo, Kent, Lenawee, Macomb, Marquette, Mecosta, Monroe, Montmorency, Muskegon, Newaygo, Oakland, Oceana, Ogemaw, Osceola, Oscoda, Otsego, Ottawa, St. Joseph, Van Buren, Washtenaw, and Wayne Co.	Emergency (3137)
7/21/98	Thunderstorms, severe winds	2 counties: Macomb and Wayne Co.	Major Disaster (1237)
5/31/98	Thunderstorms, severe winds	13 counties: Bay, Clinton, Gratiot, Ionia, Kent, Mason, Montcalm, Muskegon, Newaygo, Oceana, Ottawa, Saginaw, and Shiawassee Co.	Major Disaster (1226)
7/2/97	Tornadoes, flooding	5 counties: Genesee, Macomb, Oakland, Saginaw, and Wayne Co.	Major Disaster (1181)
6/21-7/1/96	Rainstorms, flooding, tornado	7 counties: Bay, Lapeer, Midland, Saginaw, Sanilac, St. Clair, and Tuscola Co.	Major Disaster (1128)
12/93-5/94	Underground freeze	10 counties: Charlevoix, Cheboygan, Chippewa, Delta, Gogebic, Houghton, Mackinac, Marquette, Ontonagon, and Schoolcraft Co.	Major Disaster (1028)
9/10-19/86	Flooding	30 counties: Allegan, Arenac, Bay, Clare, Clinton, Genesee, Gladwin, Gratiot, Huron, Ionia, Isabella, Kent, Lake, Lapeer, Macomb, Manistee, Mason, Mecosta, Midland, Montcalm, Muskegon, Newaygo, Oceana, Osceola, Ottawa, Saginaw, Sanilac, Shiawassee, Tuscola, and Van Buren Co.	Major Disaster (774)
9/5-6/85	Flooding	6 counties: Alcona, Genesee, Iosco, Lapeer, Saginaw and Shiawassee Co.	Major Disaster (744)
3/12-20/82	Flooding	2 counties: Berrien and Monroe Co.	Major Disaster (654)
7/15-20/80	Severe winds	10 counties: Allegan, Berrien, Calhoun, Cass, Jackson, Ottawa, St. Joseph, Van Buren, Washtenaw, and Wayne Co.	Major Disaster (631)
5/13/80	Tornado	2 counties: Kalamazoo and Van Buren Co.	Major Disaster (621)
1/26-27/78	Blizzard, snowstorm	Statewide	Emergency (3057)
3/2/77	Drought	44 counties: Alcona, Alger, Alpena, Antrim, Arenac, Baraga, Benzie, Charlevoix, Cheboygan, Chippewa, Clare, Crawford, Delta, Dickinson, Emmet, Gladwin, Gogebic, Grand Traverse, Houghton, Iosco, Iron, Isabella, Kalkaska, Lake, Leelanau, Luce, Mackinac, Manistee, Marquette, Mason, Mecosta, Menominee, Missaukee, Montmorency, Oceana, Ogemaw, Ontonagon, Osceola, Oscoda, Otsego, Presque Isle, Roscommon, Schoolcraft, and Wexford Co.	Emergency (3035)
1/26-31/77	Blizzard, snowstorm	15 counties: Allegan, Barry, Berrien, Cass, Chippewa, Hillsdale, Kalamazoo, Kent, Monroe, Muskegon, Newaygo, Oceana, Ottawa, St. Joseph, and Van Buren Co.	Emergency (3030)

Presidential Declarations in Michigan: 1953-2013* (cont.)

Date of Incident	Type of Incident	Affected Area	Type of Declaration / Federal ID Number**
3/20/76, 3/2-7/76	Ice storm, tornadoes	29 counties: Allegan, Bay, Clare, Clinton, Genesee, Gladwin, Gratiot, Ionia, Isabella, Jackson, Kent, Lapeer, Macomb, Mecosta, Midland, Montcalm, Muskegon, Newaygo, Oakland, Oceana, Osceola, Ottawa, Roscommon, Saginaw, St. Clair, Sanilac, Shiawassee, Tuscola, and Wayne Co.	Major Disaster (495)
8/20/75-9/6/75	Rainstorms, severe winds, flooding	16 counties: Allegan, Clare, Genesee, Gratiot, Ingham, Isabella, Mecosta, Midland, Montcalm, Muskegon, Newaygo, Oceana, Osceola, Ottawa, Saginaw, and Shiawassee Co.	Major Disaster (486)
4/18-30/75	Flooding, rain, tornadoes	21 counties: Allegan, Barry, Berrien, Calhoun, Clinton, Crawford, Eaton, Genesee, Ingham, Ionia, Kalamazoo, Kent, Lapeer, Livingston, Macomb, Oakland, Ottawa, Saginaw, St. Clair, Shiawassee, and Van Buren Co.	Major Disaster (465)
4/3/74	Tornado	1 county: Hillsdale Co.	Major Disaster 429)
4/12/73	Severe storms, flooding	14 counties: Arenac, Bay, Berrien, Huron, Iosco, Macomb, Menominee, Monroe, Saginaw, Sanilac, St. Clair, Tuscola, Van Buren, and Wayne Co.	Major Disaster (371)
12/1/72	Severe storms, flooding	9 counties: Arenac, Bay, Berrien, Iosco, Macomb, Monroe, St. Clair, Tuscola, and Wayne Co.	Major Disaster (363)
4/5/72	Snowstorm, freezing rain	9 counties: Allegan, Barry, Calhoun, Clinton, Eaton, Ingham, Ionia, Jackson, and Kalamazoo Co.	Major Disaster (330)
4/11/65	Tornadoes, severe storms	16 counties: Allegan, Barry, Bay, Branch, Clinton, Eaton, Gratiot, Hillsdale, Kalamazoo, Kent, Lenawee, Monroe, Montcalm, Ottawa, Shiawassee, and Washtenaw Co.	Major Disaster (190)
4/3/56	Tornado	4 counties: Benzie, Leelanau, Manistee, and Ottawa Co.	Major Disaster (53)
6/8/53	Tornado	3 counties: Genesee, Iosco, and Monroe Co.	Major Disaster (6)
5/21/53	Tornado	1 county: St. Clair Co.	Major Disaster (4)
Totals for 1953-2013:	**34 Incidents**		**26 Major Disasters; 7 Emergencies; 1 Fire Suppression**

Notes

*Does not include separate Secretary of Agriculture or Small Business Administration (SBA) disaster declarations, which are issued under other authorities. Declarations after 1974 were issued under PL 93-288 (Disaster Relief Act), as amended by the Robert T. Stafford Disaster Relief and Emergency Assistance Act (1988) and the Disaster Mitigation Act (2000).

******Indicates federal declaration number assigned by FEMA or its predecessor agencies

Frequency Distribution of Presidential Declarations in Michigan: 1953-2013+

JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	TOTAL
3	0	3	6	6	4	4	2	4	0	1	1	34
9%	0%	9%	18%	18%	12%	12%	6%	12%	0%	3%	3%	100%

Notes

+For the incident period, not the declaration date. However, the December 1993-May 1994 underground freeze declaration was assigned to the month of May (the date of the declaration). The May 2004-June 2004 thunderstorms and flooding declaration was assigned to June (the date of the declaration). The 1976-77 drought declaration was assigned to March (the date of the declaration). The April 2013-May 2013 flooding declaration was assigned to June (the date of the declaration). Percentages may not add up to 100% due to rounding.

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Presidential Declarations in Michigan: 1974-2013†
Public and Private Damage Costs

Date of Incident	Incident	Type of Declaration / Federal ID Number	Area Covered	Public Damage: $ millions*	Private Damage: $ millions*	Public Assistance: $ millions**	Individual Assistance: $ millions**
4/3/74	Tornado	Major Disaster (429)	1 County	None	0.1	None	0.1
4/18-30/75	Flooding, rain, tornadoes	Major Disaster (465)	21 Counties	9.3	48.4	3.3	0.7
8/20/75-9/6/75	Rainstorms, severe winds, flooding	Major Disaster (486)	16 Counties	1.3	1.4	0.7	0.1
3/20/76 3/2-7/76	Ice storms, tornadoes	Major Disaster (495)	29 Counties	13.4	25.0	10.3	0.2
1/26-31/77	Blizzard, snowstorm	Emergency (3030)	15 Counties	7.9	2.3	0.9	None
3/2/77	Drought	Emergency (3035)	44 Counties	N/A	None	N/A	None
1/26-27/78	Blizzard, snowstorm	Emergency (3057)	Statewide	18.7	4.3	10.0	None
5/13/80	Tornado	Major Disaster (621)	2 Counties	2.2	40.3	0.6	0.1
7/15-20/80	Severe winds	Major Disaster (631)	10 Counties	17.2	134.2	7.3	None
3/12-20/82	Flooding	Major Disaster (654)	2 Counties	2.4	8.6	None	0.1
9/5-6/85	Flooding	Major Disaster (744)	6 Counties	4.8	41.8	2.4	3.5
9/10-19/86	Flooding	Major Disaster (774)	30 Counties	67.3	137.9	14.8	16.0
12/93-5/94	Underground freeze	Major Disaster (1028)	10 Counties	7.1	None	5.7	None
6/21-7/1/96	Rainstorms, flooding, tornado	Major Disaster (1128)	7 Counties	10.4	15.3	7.4	13.8
7/2/97	Tornadoes, flooding	Major Disaster (1181)	5 Counties	31.6	28.6	31.2	12.4
5/31/98	Thunderstorms, severe winds	Major Disaster (1226)	13 Counties	35.9	1.1	36.2	None
7/21/98	Thunderstorms, severe winds	Major Disaster (1237)	2 Counties	6.9	2.0	7.4	None
1/2-15/99	Blizzard, snowstorm	Emergency (3137)	31 Counties	11.5	None	11.5	None
5/2-10/99	Wildfire	Fire Suppression	2 Counties	1.0	13.5	1.0	None
9/10-11/00	Urban flooding	Major Disaster (1346)	2 Counties	0.3	7.3‡	(HMA only) 33.2	217.9‡
12/11-31/00	Blizzard, snowstorm	Emergency (3160)	39 Counties	11.7	None	11.7	None
4/10/02-5/9/02	Flooding	Major Disaster (1413)	6 Counties	10.8	1.3	10.8	None
8/14-17/03	Electric power failure	Emergency (3189)	14 Counties	20.3	None	5.0	None
5/20/04-6/8/04	Thunderstorms, flooding	Major Disaster (1527)	23 Counties	7.4	13.3‡	(HMA only) 3.1	82.4‡
9/7/05-2/28/06	Hurricane evacuation	Emergency (3225)	Statewide	N/A	None	2.1	None
6/6/08-6/13/08	Thunderstorms, flooding	Major Disaster (1777)	12 Counties	19.9	9.2	17.3	N/A
4/16/13-5/14/13	Flooding	Major Disaster (4121)	16 Counties	18.5	3.8	27.3	None
Totals for 1974-2013:	**27 Incidents**	**19 Major Disaster; 7 Emergency; 1 Fire Suppression**		**337.8**	**539.7**	**255.2*** **	**347.3**

Table Summary:

Total Reported Public and Private Damage: ..... $877.5 Million
Total Federal Disaster Grants Received: ..... $608.5 Million
Percent of Damages Covered by Grants: 69%

Notes

† Under PL 93-288, as amended.

None = category of assistance not authorized under the declaration or category of damage not applicable; N/A = figures are not available.

*Private damage totals do NOT include agricultural damage. Public and private damage totals are estimates based on initial damage assessment reports submitted to the State Emergency Operations Center **or** more refined totals from the federal/state Preliminary Damage Assessment (PDA). Some private damage costs were reimbursed by private insurance payouts.

Public and Individual Assistance totals do **NOT include disaster loans; **ONLY** grants are included.

***Column total and individual cells Include FEMA public assistance, FHWA emergency relief assistance – if applicable, and FEMA hazard mitigation assistance – if applicable.

‡The PDA for private damage in these two disasters significantly underestimated the amount of individual assistance required. As a result, the individual assistance figures are considerably higher than the PDA private damage estimates.

Governor's Declarations in Michigan: 1977-2013

Date of Incident	Type of Incident	Affected Area	Type of Declaration**
2010-present			
6/18/13 5/7/13	Flooding	Allegan, Baraga, Barry, Benzie, Genesee, Gogebic, Gratiot, Houghton, Ionia, Iron, Kent, Keweenaw, Marquette, Mecosta, Midland, Muskegon, Newaygo, Ontonagon, Osceola, Ottawa and Saginaw Co.; City of Grand Rapids (Kent Co.); City of Ionia (Ionia Co.)	Disaster
5/25/12	Wildfire	Luce and Schoolcraft Co.	Disaster
5/11/12	Flooding	Genesee County	Emergency
5/31/11	Thunderstorms	City of Battle Creek (Calhoun Co.); Calhoun Co.	Emergency
7/27/10	Oil pipeline spill	Calhoun Co.	Disaster
6/9/10	Thunderstorms, tornadoes	Monroe Co.	Emergency
2010-13 Total:	**6 Incidents**		
2000-09			
7/21/09	Tanker truck explosion, fire	Oakland Co.	Emergency
6/19/08 6/19/08 6/19/08 6/19/08 6/19/08	Thunderstorms Thunderstorms Thunderstorms Thunderstorms Thunderstorms	Manistee Co. Wexford Co. Lake Co. Ottawa Co. Osceola Co.	Emergency+ Emergency+ Emergency+ Emergency+ Emergency+
6/13/08 6/13/08 6/13/08 6/13/08 6/13/08	Thunderstorms Thunderstorms Thunderstorms Thunderstorms Thunderstorms	City of Saginaw (Saginaw Co.) Eaton Co. Allegan Co. City of Lansing (Ingham Co.) Mason Co.	Emergency+ Emergency+ Emergency+ Emergency+ Emergency+
8/27/07	Tornado	City of Fenton (Genesee Co.)	Emergency
8/10/07 8/9/07	Wildfire	Luce Co.	Emergency
7/28/06	Thunderstorms, heavy rain	Oscoda Co.	Emergency
2/27/06	Severe winds, ice storm	Montcalm Co.	Emergency
9/4/05	Hurricane evacuation	All 83 counties	Disaster
6/3/04	Thunderstorms, flooding	Arenac, Barry, Berrien, Cass, Genesee, Gladwin, Ingham, Ionia, Jackson, Kent, Livingston, Macomb, Mecosta, Newaygo, Oakland, Ottawa, Saginaw, St. Clair, St. Joseph, Sanilac, Shiawassee, Van Buren and Wayne Co.	Disaster
4/30/04	Insect infestation (Emerald Ash Borer)	Genesee, Ingham, Jackson, Lapeer, Livingston, Macomb, Monroe, Oakland, Washtenaw and Wayne Co.; City of Allen Park (Wayne Co.); City of Ann Arbor (Washtenaw Co.); City of Birmingham (Oakland Co.); City of Dearborn (Wayne Co.); City of Dearborn Heights (Wayne Co.); City of Detroit (Wayne Co.); City of Fraser (Macomb Co.); City of Livonia (Wayne Co.); City of River Rouge (Wayne Co.); City of Romulus (Wayne Co.); City of Southfield (Oakland Co.); City of Sterling Heights (Macomb Co.); City of Trenton (Wayne Co.); City of Warren (Macomb Co.); City of Wayne (Wayne Co.); Bloomfield Township (Oakland Co.); Canton Township (Wayne Co.); Charter Township of Plymouth (Wayne Co.); Lathrup Village (Oakland Co.)	Emergency
8/15/03	Electric power failure	Macomb, Monroe, Oakland, Washtenaw, and Wayne Co.	Emergency
5/15/03	Flooding	City of Marquette, Marquette Township, and Negaunee Township (Marquette Co.)	Emergency
5/10/02 4/30/02 4/16/02	Flooding	Baraga, Houghton, Iron, Marquette, and Ontonagon Co.; City of Ironwood (Gogebic Co.)	Disaster
12/29/01	Heavy snow	Emmet Co.	Emergency
10/26/01	Severe winds	Kalamazoo Co.	Disaster
3/9/01	Flooding	Genesee Co.	Disaster
9/20/00	Urban flooding	Wayne Co.	Disaster
6/7/00	Gasoline pipeline rupture	Blackman Twp. (Jackson Co.)	Emergency
2000-09 Total:	**17 Incidents**		
1990-99			
8/5/99	Subsidence (mine shaft cave-in)	Dickinson Co.	Emergency

Governor's Declarations in Michigan: 1977-2013 (cont.)

Date of Incident	Type of Incident	Affected Area	Type of Declaration**
1990-99 (cont.)			
7/5/99	Tornado	Oscoda Co.	Disaster
1/15/99	Blizzard, snowstorm	City of Detroit (Wayne Co.)	Emergency
9/27/98	Severe winds	Otsego Co.	Emergency
9/1/98	Thunderstorms, severe winds	City of Niles (Berrien Co.)	Emergency
7/24/98 7/23/98	Thunderstorms, severe winds	Wayne Co.; City of Dearborn (Wayne Co.); City of Warren (Macomb Co.)	Disaster
6/5/98 6/4/98 6/3/98	Thunderstorms, severe winds	Bay, Clinton, Gratiot, Ionia, Kent, Mason, Mecosta, Montcalm, Muskegon, Newaygo, Oceana, Ottawa, Saginaw, and Shiawassee Co.; Village of Armada (Macomb Co.)	Disaster
4/1/98	Flooding	Alpena Co.	Emergency
7/6/97 7/3/97	Tornadoes, flooding	Genesee, Macomb, Oakland and Wayne Co.; City of Detroit (Wayne Co.); Village of Chesaning (Saginaw Co.)	Disaster
6/27/97	Rainstorms, flooding	Allegan and Ottawa Co.	Disaster
6/26/96 6/21/96	Rainstorms, flooding, tornado	Bay, Lapeer, Saginaw, Sanilac, St. Clair, and Tuscola Co.; City of Midland (Midland Co.)	Disaster
5/22/96	Flooding	Berrien Co.	Disaster
12/13/95	Snowstorm	City of Sault St. Marie (Chippewa Co.)	Emergency
7/8/94	Flooding	Lapeer, Tuscola and Sanilac Co.	Disaster
3/10/94 3/4/94 2/25/94 2/23/94	Underground freeze	Charlevoix, Cheboygan, Chippewa, Delta, Gogebic, Houghton, Mackinac, Marquette, Ontonagon, and Schoolcraft Co.	Emergency
4/20/93	Flash flood	Shiawassee Co.	Disaster
7/16/92	Heavy rain	Gogebic Co.	Disaster
7/14/92	Tornado	Cass Co.	Disaster
10/6/90	Tornado	Genesee Co.	Disaster
9/16/90	Ship explosion, fire	Bay Co.	Emergency
5/9/90	Wildfire	Crawford Co.	Emergency
1990-99 Total:	**21 Incidents**		
1980-89			
6/8/89	Flooding, severe winds	Branch, Kalamazoo and St. Joseph Co.; Village of Manchester (Washtenaw Co.)	Disaster
6/9/88	Fire	City of Corunna (Shiawassee Co.)	Disaster
8/18/87	Airline crash	City of Romulus (Wayne Co.)	Disaster
10/28/86 9/15/86 9/12/86	Flooding, heavy rain	Allegan, Arenac, Bay, Clare, Clinton, Genesee, Gladwin, Gratiot, Huron, Ionia, Isabella, Kent, Lake, Lapeer, Macomb, Manistee, Mason, Mecosta, Midland, Montcalm, Muskegon, Newaygo, Oceana, Osceola, Ottawa, Saginaw, Shiawassee, Tuscola, and Van Buren Co.	Disaster
2/21/86	Great Lakes flooding, wave action	Allegan, Arenac, Bay, Berrien, Grand Traverse, Iosco, Macomb, Marquette, Menominee, Monroe, Muskegon, Ottawa, Saginaw, St. Clair, Tuscola, Van Buren, and Wayne Co.	Disaster
9/13/85	Heavy rain, flash flood	Alcona Co.	Disaster
9/10/85	Heavy rain, flooding	Genesee, Lapeer, and Saginaw Co.	Disaster
4/13/85	Great Lakes flooding, wave action	Arenac, Bay, Macomb, Monroe, Saginaw, St. Clair, Tuscola, and Wayne Co.	Disaster
1/15/85	Ice storm	Allegan, Barry, Berrien, Calhoun, Eaton, Genesee, Ingham, Jackson, Kalamazoo, Lapeer, Livingston, Oakland, and Van Buren Co.	Disaster***
7/15/83	Wildfire	Schoolcraft Co.	Disaster
3/19/82	Flooding	Berrien and Monroe Co.	Disaster
7/21/80	Thunderstorms, severe winds	Allegan, Berrien, Calhoun, Cass, Jackson, St. Joseph, Van Buren, Washtenaw, and Wayne Co.; City of Grand Haven and Village of Spring Lake (Ottawa Co.)	Disaster
5/13/80	Tornado	Kalamazoo and Van Buren Co.	Disaster
1980-89 Total:	**13 Incidents**		

Governor's Declarations in Michigan: 1977-2013 (cont.)

Date of Incident	Type of Incident	Affected Area	Type of Declaration**
1977-79			
8/9/78	Sewer main break	Macomb Co.	Disaster
6/30/78	Thunderstorms, severe winds, hail, rain	Berrien Co.	Disaster
6/28/78	Thunderstorms	Allegan Co.	Disaster
1/26/78	Blizzard, snowstorm	Statewide	Disaster
12/10/77	Snowstorm	City of Hamtramck (Wayne Co.)	Disaster
4/6/77	Tornado, severe winds	Clinton, Eaton, Kalamazoo, and Livingston Co.	Disaster
1/28/77	Blizzard	Allegan, Barry, Berrien, Cass, Chippewa, Eaton, Hillsdale, Ionia, Muskegon, Newaygo, Oceana, Ottawa, Sanilac, Shiawassee, and Van Buren Co.	Disaster
1977-79 Total:	**7 Incidents**		
Totals for 1977-2013	**64 Incidents**		**41 Disaster Declarations; 23 Emergency Declarations**

Notes

**Declarations since 1977 were issued under 1976 PA 390, as amended (Michigan Emergency Management Act).

***A "State of Emergency" was also declared for this incident under 1945 PA 302 (Emergency Powers of Governor Act).

+Some incidents have resulted in multiple declarations for the same incident (each jurisdiction declared separately). These are counted as one declaration only for the purposes of this list.

Frequency Distribution of Governor's Declarations in Michigan: 1977-2013*

JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	TOTAL
4	3	2	6	8	11	11	6	8	2	0	3	64
6%	5%	3%	9%	13%	17%	17%	9%	13%	3%	0%	5%	100%

Notes

*For the declaration date, not the incident period. Percentages may not add up to 100% due to rounding.

Governor's and Presidential Declarations by County: 1953-2013*

Jurisdiction	# of Governor's Declarations	Dates**	# of Presidential Declarations	Dates**
COUNTIES				
Alcona County	3	9/05; 9/85; 1/78	5	9/05; 1/99; 9/85; 1/78; 3/77
Alger County	2	9/05; 1/78	3	9/05; 1/78; 3/77
Allegan County	11	6/13; 6/08; 9/05; 6/97; 9/86; 2/86; 1/85; 7/80; 6/78; 1/78; 1/77	14	6/13; 7/08; 9/05; 1/01; 1/99; 9/86; 7/80; 1/78; 1/77; 3/76; 9/75; 4/75; 4/72; 4/65
Alpena County	3	9/05; 4/98; 1/78	3	9/05; 1/78; 3/77
Antrim County	2	9/05; 1/78	3	9/05; 1/78; 3/77
Arenac County	6	9/05; 6/04; 9/86; 2/86; 4/85; 1/78	7	9/05; 1/99; 9/86; 1/78; 3/77; 4/73; 12/72
Baraga County	4	5/13; 9/05; 4/02; 1/78	5	6/13; 9/05; 5/02; 1/78; 3/77
Barry County	6	5/13; 9/05; 6/04; 1/85; 1/78; 1/77	11	6/13; 7/08; 9/05; 6/04; 1/01; 1/99; 1/78; 1/77; 4/75; 4/72; 4/65
Bay County	8	9/05; 6/98; 6/96; 9/90; 9/86; 2/86; 4/85; 1/78	10	9/05; 1/01; 6/98; 7/96; 9/86; 1/78; 3/76; 4/73; 12/72; 4/65
Benzie County	3	5/13; 9/05; 1/78	4	9/05; 1/78; 3/77; 4/56
Berrien County	10	9/05; 6/04; 5/96; 2/86; 1/85; 3/82; 7/80; 6/78; 1/78; 1/77	11	9/05; 6/04; 1/01; 1/99; 3/82; 7/80; 1/78; 1/77; 4/75; 4/73; 12/72

Governor's and Presidential Declarations by County: 1953-2013* (cont.)

Jurisdiction	# of Governor's Declarations	Dates**	# of Presidential Declarations	Dates**
COUNTIES (cont.)				
Branch County	3	9/05; 6/89; 1/78	4	9/05; 1/01; 1/78; 4/65
Calhoun County	6	5/11; 7/10; 9/05; 1/85; 7/80; 1/78	7	9/05; 8/03; 1/01; 7/80; 1/78; 4/75; 4/72
Cass County	6	9/05; 6/04; 7/92; 7/80; 1/78; 1/77	7	9/05; 6/04; 1/01; 1/99; 7/80; 1/78; 1/77
Charlevoix County	3	9/05; 3/94; 1/78	4	9/05; 5/94; 1/78; 3/77
Cheboygan County	3	9/05; 3/94; 1/78	4	9/05; 5/94; 1/78; 3/77
Chippewa County	4	9/05; 3/94; 1/78; 1/77	5	9/05; 5/94; 1/78; 3/77; 1/77
Clare County	3	9/05; 9/86; 1/78	7	9/05; 1/01; 9/86; 1/78; 3/77; 3/76; 9/75
Clinton County	5	9/05; 6/98; 9/86; 1/78; 4/77	9	9/05; 1/01; 6/98; 9/86; 1/78; 3/76; 4/75; 4/72; 4/65
Crawford County	3	9/05; 5/90; 1/78	5	9/05; 1/99; 1/78; 3/77; 4/75
Delta County	3	9/05; 3/94; 1/78	4	9/05; 5/94; 1/78; 3/77
Dickinson County	3	9/05; 8/99; 1/78	3	9/05; 1/78; 3/77
Eaton County	6	6/08; 9/05; 1/85; 1/78; 4/77; 1/77	9	7/08; 9/05; 6/04; 8/03; 1/01; 1/78; 4/75; 4/72; 4/65
Emmet County	3	9/05; 12/01; 1/78	3	9/05; 1/78; 3/77
Genesee County	12	5/13; 5/12; 9/05; 6/04; 4/04; 3/01; 7/97; 10/90; 9/86; 9/85; 1/85; 1/78	12	9/05; 6/04; 8/03; 1/01; 7/97; 9/86; 9/85; 1/78; 3/76; 9/75; 4/75; 6/53
Gladwin County	4	9/05; 6/04; 9/86; 1/78	7	9/05; 6/04; 1/01; 9/86; 1/78; 3/77; 3/76
Gogebic County	5	5/13; 9/05; 2/94; 7/92; 1/78	6	6/13; 9/05; 5/02; 5/94; 1/78; 3/77
Gd. Traverse County	3	9/05; 2/86; 1/78	3	9/05; 1/78; 3/77
Gratiot County	5	5/13; 9/05; 6/98; 9/86; 1/78	8	9/05; 1/01; 6/98; 9/86; 1/78; 3/76; 4/75; 4/65
Hillsdale County	3	9/05; 1/78; 1/77	7	9/05; 8/03; 1/01; 1/78; 1/77; 4/74; 4/65
Houghton County	5	5/13; 9/05; 4/02; 2/94; 1/78	6	6/13; 9/05; 5/02; 5/94; 1/78; 3/77
Huron County	3	9/05; 9/86; 1/78	5	9/05; 1/01; 9/86; 1/78; 4/73
Ingham County	5	9/05; 6/04; 4/04; 1/85; 1/78	9	7/08; 9/05; 6/04; 8/03; 1/01; 1/78; 9/75; 4/75; 4/72
Ionia County	7	5/13; 9/05; 6/04; 6/98; 9/86; 1/78; 1/77	11	6/13; 9/05; 6/04; 1/01; 1/99; 6/98; 9/86; 1/78; 3/76; 4/75; 4/72
Iosco County	3	9/05; 2/86; 1/78	8	9/05; 1/99; 9/85; 1/78; 3/77; 4/73; 12/72; 6/53
Iron County	4	6/13; 9/05; 5/02; 1/78	4	9/05; 5/02; 1/78; 3/77
Isabella County	3	9/05; 9/86; 1/78	7	9/05; 1/01; 9/86; 1/78; 3/77; 3/76; 9/75
Jackson County	6	9/05; 6/04; 4/04; 1/85; 7/80; 1/78	8	9/05; 6/04; 1/01; 1/99; 7/80; 1/78; 3/76; 4/72
Kalamazoo County	7	9/05; 10/01; 6/89; 1/85; 5/80; 1/78; 4/77	10	9/05; 8/03; 1/01; 1/99; 5/80; 1/78; 1/77; 4/75; 4/72; 4/65
Kalkaska County	2	9/05; 1/78	3	9/05; 1/78; 3/77
Kent County	6	5/13; 9/05; 6/04; 6/98; 9/86; 1/78	12	6/13; 9/05; 6/04; 1/01; 1/99; 6/98; 9/86; 1/78; 1/77; 3/76; 4/75; 4/65
Keweenaw County	3	5/13; 9/05; 1/78	3	6/13; 9/05; 1/78
Lake County	4	6/08; 9/05; 9/86; 1/78	5	7/08; 9/05; 9/86; 1/78; 3/77
Lapeer County	8	9/05; 4/04; 6/96; 7/94; 9/86; 9/85; 1/85; 1/78	9	9/05; 8/03; 1/01; 7/96; 9/86; 9/85; 1/78; 3/76; 4/75
Leelanau County	2	9/05; 1/78	4	9/05; 1/78; 3/77; 4/56
Lenawee County	2	9/05; 1/78	4	9/05; 1/99; 1/78; 4/65
Livingston County	6	9/05; 6/04; 4/04; 1/85; 1/78; 4/77	6	9/05; 6/04; 8/03; 1/01; 1/78; 4/75
Luce County	4	5/12; 8/07; 9/05; 1/78	3	9/05; 1/78; 3/77
Mackinac County	3	9/05; 2/94; 1/78	4	9/05; 5/94; 1/78; 3/77
Macomb County	10	9/05; 6/04; 4/04; 8/03; 7/97; 9/86; 2/86; 4/85; 8/78; 1/78	13	9/05; 6/04; 8/03; 1/01; 1/99; 7/98; 7/97; 9/86; 1/78; 3/76; 4/75; 4/73; 12/72
Manistee County	4	6/08; 9/05; 9/86; 1/78	6	7/08; 9/05; 9/86; 1/78; 3/77; 4/56
Marquette County	6	5/13; 9/05; 4/02; 2/94; 2/86; 1/78	7	6/13; 9/05; 5/02; 1/99; 5/94; 1/78; 3/77

Governor's and Presidential Declarations by County: 1953-2013* (cont.)

Jurisdiction	# of Governor's Declarations	Dates**	# of Presidential Declarations	Dates**
COUNTIES (cont.)				
Mason County	5	6/08; 9/05; 6/98; 9/86; 1/78	6	7/08; 9/05; 6/98; 9/86; 1/78; 3/77
Mecosta County	6	5/13; 9/05; 6/04; 6/98; 9/86; 1/78	9	9/05; 6/04; 1/01; 1/99; 9/86; 1/78; 3/77; 3/76; 9/75
Menominee County	3	9/05; 2/86; 1/78	4	9/05; 1/78; 3/77; 4/73
Midland County	4	5/13; 9/05; 2/86; 1/78	8	6/13; 9/05; 1/01; 7/96; 9/86; 1/78; 3/76; 9/75
Missaukee County	2	9/05; 1/78	4	7/08; 9/05; 1/78; 3/77
Monroe County	8	6/10; 9/05; 4/04; 8/03; 2/86; 4/85; 3/82; 1/78	10	9/05; 8/03; 1/99; 3/82; 1/78; 1/77; 4/73; 12/72; 4/65; 6/53
Montcalm County	5	2/06; 9/05; 6/98; 9/86; 1/78	8	9/05; 1/01; 6/98; 9/86; 1/78; 3/76; 9/75; 4/65
Montmorency County	2	9/05; 1/78	4	9/05; 1/99; 1/78; 3/77
Muskegon County	7	5/13; 9/05; 6/98; 9/86; 2/86; 1/78; 1/77	11	6/13; 9/05; 6/04; 1/01; 1/99; 6/98; 9/86; 1/78; 1/77; 3/76; 9/75
Newaygo County	7	5/13; 9/05; 6/04; 6/98; 9/86; 1/78; 1/77	9	6/13; 9/05; 1/99; 6/98; 9/86; 1/78; 1/77; 3/76; 9/75
Oakland County	8	7/09; 9/05; 6/04; 4/04; 8/03; 7/97; 1/85; 1/78	10	9/05; 6/04; 8/03; 1/01; 10/00; 1/99; 7/97; 1/78; 3/76; 4/75
Oceana County	5	9/05; 6/98; 9/86; 1/78; 1/77	9	9/05; 1/99; 6/98; 9/86; 1/78; 3/77; 1/77; 3/76; 9/75
Ogemaw County	2	9/05; 1/78	4	9/05; 1/99; 1/78; 3/77
Ontonagon County	5	5/13; 9/05; 4/02; 2/94; 1/78	6	6/13; 9/05; 5/02; 5/94; 1/78; 3/77
Osceola County	5	5/13; 6/08; 9/05; 9/86; 1/78	10	6/13; 7/08; 9/05; 1/01; 1/99; 9/86; 1/78; 3/77; 3/76; 9/75
Oscoda County	4	7/06; 9/05; 7/99; 1/78	4	9/05; 1/99; 1/78; 3/77
Otsego County	3	9/05; 9/98; 1/78	4	9/05; 1/99; 1/78; 3/77
Ottawa County	10	5/13; 6/08; 9/05; 6/04; 6/98; 6/97; 9/86; 2/86; 1/78; 1/77	16	6/13; 7/08; 9/05; 6/04; 1/01; 1/99; 6/98; 9/86; 7/80; 1/78; 1/77; 3/76; 9/75; 4/75; 4/65; 4/56
Presque Isle County	2	9/05; 1/78	3	9/05; 1/78; 3/77
Roscommon County	2	9/05; 1/78	4	9/05; 1/78; 3/77; 3/76
Saginaw County	10	5/13; 9/05; 6/04; 6/98; 6/96; 9/86; 2/86; 9/85; 4/85; 1/78	15	6/13; 7/08; 9/05; 6/04; 1/01; 6/98; 7/97; 7/96; 9/86; 9/85; 1/78; 3/76; 9/75; 4/75; 4/73
St. Clair County	6	9/05; 6/04; 6/96; 2/86; 4/85; 1/78	11	9/05; 6/04; 8/03; 1/01; 7/96; 1/78; 3/76; 4/75; 4/73; 12/72; 5/53
St. Joseph County	5	9/05; 6/04; 6/89; 7/80; 1/78	7	9/05; 6/04; 1/01; 1/99; 7/80; 1/78; 1/77
Sanilac County	6	9/05; 6/04; 6/96; 7/94; 1/78; 1/77	8	9/05; 6/04; 1/01; 7/96; 9/86; 1/78; 3/76; 4/73
Schoolcraft County	5	5/12; 9/05; 2/94; 7/83; 1/78	4	9/05; 5/94; 1/78; 3/77
Shiawassee County	7	9/05; 6/04; 6/98; 4/93; 9/86; 1/78; 1/77	11	9/05; 6/04; 1/01; 6/98; 9/86; 9/85; 1/78; 3/76; 9/75; 4/75; 4/65
Tuscola County	6	9/05; 7/94; 9/86; 2/86; 4/85; 1/78	8	9/05; 1/01; 7/96; 9/86; 1/78; 3/76; 4/73; 12/72
Van Buren County	9	9/05; 6/04; 9/86; 2/86; 1/85; 7/80; 5/80; 1/78; 1/77	10	9/05; 1/01; 1/99; 9/86; 7/80; 5/80; 1/78; 1/77; 4/75; 4/73
Washtenaw County	5	9/05; 4/04; 8/03; 7/80; 1/78	8	9/05; 6/04; 8/03; 1/01; 1/99; 7/80; 1/78; 4/65
Wayne County	11	9/05; 6/04; 4/04; 8/03; 9/00; 7/98; 7/97; 2/86; 4/85; 7/80; 1/78	12	9/05; 6/04; 8/03; 10/00; 1/99; 7/98; 7/97; 7/80; 1/78; 3/76; 4/73; 12/72
Wexford County	3	6/08; 9/05; 1/78	4	7/08; 9/05; 1/78; 3/77

Governor's Declarations by Municipality: 1977-2013

Jurisdiction	# of Governor's Declarations	Dates*
MUNICIPALITIES		
City of Grand Rapids (Kent County)	1	5/13
City of Ionia (Ionia County)	1	5/13
City of Battle Creek (Calhoun County)	1	5/11
City of Saginaw (Saginaw County)	1	6/08
City of Lansing (Ingham County)	1	6/08
City of Fenton (Genesee County)	1	8/07
City of Allen Park (Wayne County)	1	4/04
City of Ann Arbor (Washtenaw County)	1	4/04
City of Birmingham (Oakland County)	1	4/04
City of Dearborn Heights (Wayne County)	1	4/04
City of Fraser (Macomb County)	1	4/04
City of Livonia (Wayne County)	1	4/04
City of River Rouge (Wayne County)	1	4/04
City of Southfield (Oakland County)	1	4/04
City of Sterling Heights (Macomb County)	1	4/04
City of Trenton (Wayne County)	1	4/04
City of Wayne (Wayne County)	1	4/04
Bloomfield Township (Oakland County)	1	4/04
Canton Township (Wayne County)	1	4/04
Charter Township of Plymouth (Wayne County)	1	4/04
Lathrup Village (Oakland County)	1	4/04
Negaunee Township (Marquette County)	1	5/03
Marquette Township (Marquette County)	1	5/03
City of Ironwood (Gogebic County)	1	4/02
Blackman Township (Jackson County)	1	6/00
City of Niles (Berrien County)	1	9/98
City of Warren (Macomb County)	2	7/98; also 4/04
City of Dearborn (Wayne County)	2	7/98; also 4/04
Village of Armada (Macomb County)	1	6/98
City of Detroit (Wayne County)	3	7/97; also 4/04, 1/99
Village of Chesaning (Saginaw County)	1	7/97
City of Midland (Midland County)	1	6/96
City of Sault Ste. Marie (Chippewa County)	1	12/95
City of Marquette (Marquette County)	2	2/94; also 5/03
City of Negaunee (Marquette County)	1	2/94
City of Ishpeming (Marquette County)	1	2/94
Powell Township (Marquette County)	1	2/94
Village of Manchester (Washtenaw County)	1	6/89
City of Corunna (Shiawassee County)	1	6/88
City of Romulus (Wayne County)	2	8/87; also 4/04
City of Grand Haven (Ottawa County)	1	7/80
Village of Spring Lake (Ottawa County)	1	7/80
City of Hamtramck (Wayne County)	1	12/77

*Many municipal declarations issued concurrent with a county declaration.

State Disaster Contingency Fund Grants: 1994-2013
(1976 Public Act 390, as amended, MCL 30.419)

Year*	Jurisdiction(s)	Type of Incident	Number of Grants	Total Paid ($)
1994	Lapeer, Sanilac and Tuscola Co.	Flooding	28	363,982
1997	Allegan and Ottawa Co.	Flooding	12	125,213
1997	Oakland Co.	Tornadoes	5	87,419
1998	Alpena Co.	Flooding	8	160,308
1998	Mecosta Co.; Village of Armada	Thunderstorms	4	60,809
1998	City of Niles	Thunderstorms	1	30,000
1998	Otsego Co.	Severe winds	4	78,946
1999	Oscoda Co.	Tornado	2	36,910
2001	Genesee Co.	Flooding	1	14,637
2002	Kalamazoo Co.	Severe winds	9	218,461
2006	Oscoda Co. (and state agency response)	Thunderstorms	1	50,000
2010	Monroe Co.	Tornadoes	6	134,627
2011	Calhoun Co. (and state agency response)	Thunderstorms	5	241,387
2012	Genesee Co.	Flooding	3	90,000
TOTALS:			**89**	**1,692,699**

*Indicates year in which payments were made.

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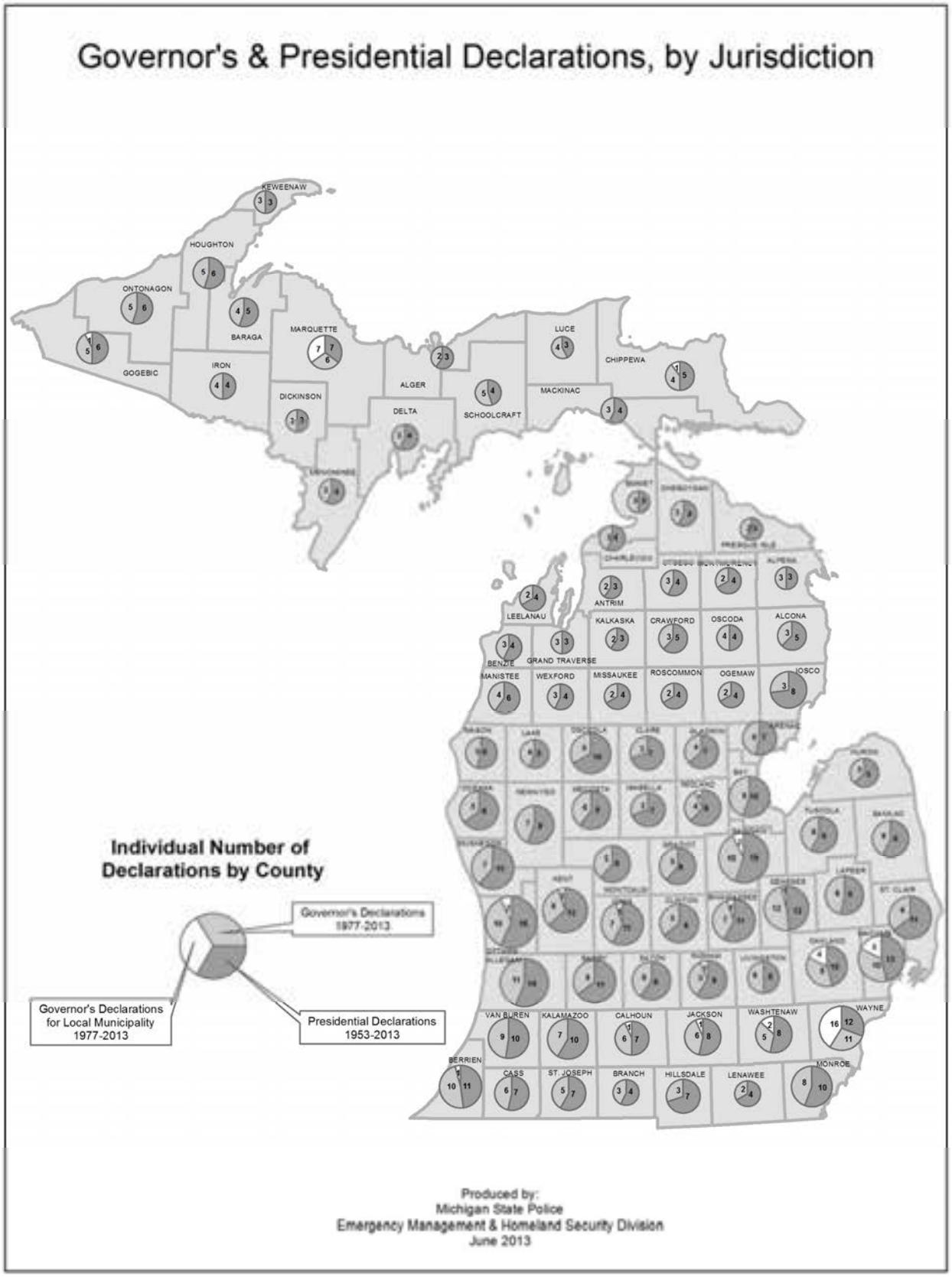
Governor's & Presidential Declarations, by Jurisdiction
KEWEENAW
HOUGHTON
ONTONAGON
BARAGA
GOGEBIC
IRON
MARQUETTE
DICKINSON
ALGER
DELTA
SCHOOLCRAFT
LUCE
CHIPPEWA
MACKINAC
ANTRIM
LEELANAU
KALKASKA
CRAWFORD
OSCODA
ALCONA
BENZIE
GRAND TRAVERSE
MANISTEE
WEXFORD
MISSAUKEE
ROSCOMMON
OGEMAW
IOSCO
VAN BUREN
KALAMAZOO
CALHOUN
JACKSON
WASHTENAW
WAYNE
BERRIEN
CASS
ST. JOSEPH
BRANCH
HILLSDALE
LENAWEE
MONROE
Individual Number of Declarations by County
Governor's Declarations 1977-2013
Governor's Declarations for Local Municipality 1977-2013
Presidential Declarations 1953-2013
Produced by:
Michigan State Police
Emergency Management & Homeland Security Division
June 2013

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Attachment C: Funding Sources for Hazard Mitigation

This subsection of the Michigan Hazard Mitigation Plan starts by providing a comprehensive overview of hazard mitigation funding sources and projects. It can serve as a "roadmap" to more detailed information sources available on the Internet, using the Catalog of Federal Domestic Assistance (CFDA) web site, as well as the numerous web sites for the federal and state agencies and private philanthropic organizations that are referred to in this section. It is meant to supplement the descriptive section on Mitigation Opportunities, Recommendations, and Implementation, in the main body of the Plan.

After an initial section that presents general techniques and resources for use in seeking and obtaining grant funding, a second section then presents funding sources for state and federal agency program information and nonprofit organizations and foundations (focusing on programs that may be useful for hazard mitigation projects). This is followed by a third section that describes the scoring and prioritization process used for project applications submitted to the State of Michigan. Finally, the lengthy fourth section of this Attachment summarizes all of the hazard mitigation grant projects that have gone through this selection process in Michigan, including a statewide map that displays the locations of these projects.

(NOTE: Some of the material in this section had originally been presented as a separate document, EMD-Pub. 207a, called "Funding Sources for Hazard Mitigation." This material was integrated within the 2011 edition of the Michigan Hazard Mitigation Plan.)

Hazard Mitigation Funding Mechanisms

This Attachment to the Michigan Hazard Mitigation Plan provides a compendium of Federal, state, and private sector funding sources for hazard mitigation projects, and is intended to serve as a tool for local communities to use in developing funding "packages" to implement hazard mitigation projects in support of their hazard mitigation plan. It is NOT the "be-all, end-all" information source for hazard mitigation project funding. Rather, it is intended to serve as a roadmap to other, more detailed information sources such as the Catalog of Federal Domestic Assistance (CFDA), Federal and State Agency web sites, and private philanthropic organization web sites.

Funding sources open to local governments or that directly or indirectly benefit local governments, are listed in this compendium. Those programs that benefit a designated group only (i.e., Indian Tribes) are not included, nor are those programs for which a State Agency is the only eligible applicant. (However, it is possible that projects could be funded under a partnership arrangement with a State Agency. Such requests would have to be directed in writing to that agency.)

This document was compiled by staff of the Mitigation Unit of the Emergency Management and Homeland Security Division, Michigan Department of State Police, using available information sources at the time of publication. As new programs and funding opportunities become available in the future, every attempt will be made to revise this compendium in a timely manner (within staff capabilities and resources). If you are aware of a potential hazard mitigation funding source not listed here, please provide the information to the Mitigation Unit for future revisions.

References to specific governmental funding programs are listed according to each agency's entry in either the Federal Catalog of Domestic Assistance (for federal programs) or an agency's web site (for state programs). Further instructions and information are included on the CFDA web site. Some private sector funding sources listed do not have a web site with program information, but additional information on that program can usually be obtained through the Michigan Foundation Directory, which can be ordered from the Council of Michigan Foundations web site at http://www.michiganfoundations.org/s_cmf/index.asp.

The mere availability of funding for mitigation projects does not guarantee success. "Grantsmanship"—the ability to formulate projects, determine probable costs, identify probable funding sources, coordinate with project "partners", and write successful project proposals—is an essential skill for today's emergency management professionals. Someone in the community has to have the "vision" to identify potential projects, handle the mechanics of obtaining funding, and then see the project through to fruition. Grantsmanship is both an art and science. There are definite right and wrong ways to prepare project proposals. That is the science part of the equation. However, it is the "art" involved—the ability to see what others might not and then have the wherewithal to make something happen—that makes some communities successful and others not.

Fortunately, technical assistance in proposal development and grant writing is available from a variety of sources, including the Michigan Department of State Police, Office of the Budget. The Office of the Budget Grants Coordinator is available to provide limited technical assistance to local officials in developing a good project proposal and request for grant funding. This assistance can be arranged through your MSP/EMHSD District Coordinator. Many local communities may have their own Grants Coordinator on staff or under contract to assist local agencies in grant-related activities. Guidance on developing and writing grant proposals is also included in this section.

Funding Sources for Mitigation Projects

Two types of problems frequently appear when mitigation efforts are being considered. The first is when a planner or emergency manager doesn't even consider many mitigation possibilities because an area's hazards may seem too large-scale, expensive, or technically demanding for the resources of his or her community to address. On the other hand, you may have dared to "dream big" and produced a lengthy "wish list" of excellent hazard mitigation ideas for your community, but now you need to determine whether any of these solutions are realistically achievable within the technical and financial limits of your community's emergency management program. This section is intended to encourage planners to dare to "think big" in creating their ideas for hazard mitigation projects, and then to be able to realistically assess the feasibility of implementing these projects. This section hopes to enable you to explore a wider range of possibilities for gaining the technical and financial capabilities needed to implement your project ideas. Before you give up a great idea that you were bold enough to envision, you should read through this section to see if, just maybe, there is a way to assemble all the funding and technical requirements that will make it work. There may be cases where a proposal is rejected as *almost but not quite* feasible, because it lacks that last bit of funding or technical expertise that would ensure its viability for the community, and everyone wonders if there weren't some source of funding or expertise that could have provided the project with the last little "push" it needed to get rolling. Hopefully, the reader will gain more ideas and capability to implement his or her mitigation ideas as a result of this section.

"Start At Home"
(Local Sources of Funding and Technical Assistance for Mitigation Projects)

The hierarchy of emergency management functions in the United States is arranged so that assistance from higher levels of the hierarchy serves to supplement local resources when they would otherwise be exhausted. It is therefore important to ensure that local resources really are being fully utilized before appealing to state or Federal government for assistance. It is also at the local level that the clearest picture is seen of what types of projects are needed, and for what purposes. Frequently, a great amount can be accomplished at the local level alone, as emergency managers learn to build partnerships and find creative ways to accomplish mitigation-oriented tasks in coordination with other types of community improvement projects.

It is a good idea to assess what capabilities your community currently possesses with which to carry out your mitigation project ideas, and what resources will be needed from other sources. It is essential to consider the nature of the mitigation project and its scope. Who will it affect in the community? Who will benefit the most from it? Answering these questions will often point to local people and organizations who can be asked to assist or participate in implementing the mitigation project.

Some mitigation strategies involve local ordinances or construction and safety codes. This sort of project would call for the mobilization of political and popular support to achieve the mitigation objective. Some strategies may entail a public education or awareness campaign that would involve local schools, community centers, or newspapers. Other projects may be physical construction or renovation projects that require engineering expertise and lots of funding to implement. The building of local partnerships and community awareness and support often is required for all these types of projects, and so this section will present many ideas emergency managers will want to explore from the outset. It is frequently the case that the amount of assistance available locally is far greater than that which is available from outside the community.

Building Community Awareness and Support through Volunteer Resources and Organizations

It is important to have community members aware of hazards so that they are less likely themselves to act in ways that increase risks to themselves or others, or to the community's property and environment. Community awareness and support has not only an educational and political component to it, however. Every community contains people with a wide variety of skills and knowledge, and a willingness to help out in circumstances where they see a need for it. Advice, technical expertise, labor, and even funds might be available through the donations of community members who have come to believe in the importance of the mitigation objective that has been proposed. Individuals may be able to volunteer their knowledge and skills, labor, power, and money to support a good project. Local businesses may be willing to donate labor, materials, or funds for projects that benefit them. Many wealthy persons have been known to contribute generously to causes they believe in-especially if it benefits the community in which they live and work. More information on this aspect of fundraising can be found at http://staff.lib.msu.edu/harris23/grants/index.htm .

Contributions and volunteerism need not occur individually, but can be achieved through local community organizations that are able to inform their members about the need for the project and coordinate their members' efforts to promote the project's success. Many local organizations will be glad to participate in worthy local causes, and such participation helps strengthen their cohesion and sense of community as well. Local organizations are often experienced at fundraising, and frequently have members of local political importance who can be vital to the success of a mitigation project. Emergency managers should consider what kinds of local organizations are present in the community and how to involve them or their members in support of the proposed mitigation project.

The Use of Public/Private Partnerships

Emergency managers should also identify who the most important for-profit institutions are in the local community. Major employers, financial institutions, and insurance companies may all have an interest in supporting a mitigation project that benefits the community. (Such support is often needed to gain state or federal support for the project as well.) Often, large companies already have a corporate giving program or an associated foundation that will provide assistance. Utilities and transportation service providers should similarly be investigated to see if they can provide assistance. A large number of insurance organizations can be found listed at http://www.aiadc.org/

Gaining Assistance Through Creative Coordination with Other Projects and Local Government Functions

Many mitigation projects have elements of overlap with other projects, or coincide in some way with established goals of the community, some of its residents, or one of its governmental agencies. Emergency managers who have an ability to identify common elements that his/her mitigation project shares with other community or organizational activities will often be able to find ways to coordinate his/her mitigation efforts with those of the related activities. In some cases, the process may be very formal, as when a mitigation project is being linked in with some ongoing government function or project. In other cases, there may merely be some small alteration of an existing project to include mitigation goals (or to avoid interference with such goals).

A local government has many types of activities that often affect hazard mitigation prospects in the community, such as capital improvement projects, and initiatives for community and economic development. It may be that, after examining each other's projects, the emergency manager and some other local official will find that the two are mutually beneficial, and some degree of coordination can help everyone's resources go farther. In some cases where all that is needed is some staff time or technical advice, it may be very easy for mutual assistance to occur.

Sometimes, an important mitigation project may deserve some sort of distinct local government support mechanism. This could involve the use of government bonds to support the project, the formation of a benefit assessment district, or the adjustment of the municipal budget to provide funding for the project. In such cases, the emergency manager will benefit greatly from whatever popular and political support were gained through the building of community awareness discussed in item 1 above. More information on government bonds can be found through the Michigan Municipal Bond Authority, now part of the Michigan Finance Authority.
See their website at http://www.michigan.gov/treasury/0,1607,7-121-1753_55952---,00.html.

Nonprofit Organizations and Foundations

Foundations can be investigated through the Council of Michigan Foundations (www.cmif.org) or The Foundation Center (http://fdncenter.org). There are a few more web sites on foundations at www.smallfoundations.org, www.cof.org , and http://staff.lib.msu.edu/harris23/grants/privcomm.htm. Some foundations are private and some are company-sponsored. The National Science Foundation has an Earthquake Hazards Mitigation Program and a Natural and Technological Hazards Mitigation Program. In addition, Michigan has a number of *community foundations*, a list of which can be found at the website listed above. If there is no such foundation for your area, perhaps one can be organized.

Not-for-profit organizations (and grant making public charities) may also be interested in helping, and at the very least tend to be excellent sources of information, advice, and favorable publicity that almost any project can benefit from. By talking with a variety of professionals, the local emergency manager will be able to assemble a lengthy list of professional organizations pertinent to local mitigation projects. Here are some examples:

- Advocates for Highway and Auto Safety
- American Engineers for Disaster Relief
- American Institute of Architects
- American Planning Association
- American Public Works Association, Emergency Management Committee
- American Society for Civil Engineers
- Association of Contingency Planners
- Association of State Dam Safety Officials
- Association of State Floodplain Managers
- Building Officials and Code Administrators International (BOCA)
- Building Seismic Safety Council
- Business and Industry Council for Emergency Planning and Preparedness
- Center for the Study of Emergency Management
- Earthquake Engineering Research Institute
- Institute for Business and Home Safety
- Insurance Institute for Highway Safety
- Insurance Services Office
- International Association of Emergency Planners
- International City/County Management Association
- Michigan Association of County Drain Commissioners
- Michigan Fire Chiefs Association
- Michigan State Firemen's Association
- Michigan Stormwater-Floodplain Association
- National Association of State Foresters
- National Center for Earthquake Engineering Research
- National Emergency Management Association
- National Conference of States on Building Codes and Standards
- National Fire Protection Association
- National Lightning Safety Institute
- National Association of Abandoned Mine Land Programs
- State and Local Emergency Management Data Users Group
- U.S. Fire Administration

In the local section of this funding overview, local volunteer assistance was mentioned. It may also be possible to involve state or national volunteer groups as well. A good place to start is by contacting Michigan Voluntary Associations Active in Disasters (MIVOAD). The American National Red Cross, religiously-affiliated organizations (such as the Salvation Army or Catholic Relief Services), or charitable organizations such as the United Way may also be of assistance in some cases.

Governmental Assistance

Much of the information collected here on state and federal sources of assistance can be found on the Internet. The simplest way to access information on Federal government assistance is through the Catalog of Federal Domestic Assistance (CFDA). Its web address is http://www.cfda.gov/ . The program listings included in this document are organized by the reference numbers used by CFDA to make it easy for anyone to locate the program in the federal catalog.

Unfortunately, the State of Michigan has no such catalog of assistance programs making it necessary to search through information from many state agencies' web sites to come up with a list of programs. A good place to start such a general search is the Michigan Government Home Page at http://www.michigan.gov/ . Click on the State Agencies icon and then go to the specific agency desired.

For this document, searches were narrowed by focusing on activities that had a clear emphasis on, or applications toward, hazard mitigation and emergency management. However, it is possible that extra assistance may be obtained through programs not included here. As described in the section on local funding, it is sometimes possible to find areas where mitigation concerns overlap with other subjects, and to coordinate both concerns in existing projects funded from other sources. Consider the special features of your community that might be affected by hazards. Programs dealing with housing, farms, fisheries, natural resources, parks and wildlife, for example, may in some way be applicable to a particular mitigation goal in your community. There are many state and federal programs and projects dealing with pollution, the environment, conservation, and economic development. Upon discussion, their administrators might approve some mitigation components in these programs/projects, or at least ensure that hazards are not worsened by program/project implementation.

Consider also the special assistance that may be available because of the presence of particular institutions or government-owned resources. The presence of a university or military installation often means many more resources that a community can use. Such institutions can also provide assistance on technical matters involving mitigation projects, and are usually interested in providing benefits to their surrounding communities whenever the chance arises. Many universities have "extension" programs whose purpose is to find and provide such beneficial services. Many technical and engineering projects can be assisted by special research grants gained through partnering with colleges and universities, or by requesting the expertise of an organization such as the U. S. Army Corps of Engineers.

Projects dealing with school (and college) improvements may have mitigation components included in them. Other institutional facilities such as prisons, nursing homes, and health care providers should also have an interest in supporting mitigation projects that affect them. Additional funding may be available in some cases when a project involves the protection of designated historic districts or other areas of cultural or economic significance. Hazards that threaten businesses and tourism might merit funding from programs whose goal is economic development (or business attraction and retention).

In addition, areas of the community that have concentrations of persons from particular ethnic groups may provide an opportunity for organizations serving that group to become involved in mitigation projects that help maintain or improve its inhabitants' quality of life. There are a number of federal programs that make assistance available to Indian tribes, for example. Consultation with any such groups in your area might reveal useful means of facilitating or promoting mitigation projects.

More Information

There are many books and documents that give more advice on ways to collect funding information, write grant proposals, and so on. The Foundation Center has a number of libraries throughout Michigan that have extensive grants and funding information. Below is a list of the general locations, with web sites. A complete list with address, phone and contact information can be found at http://staff.lib.msu.edu/harris23/grants/michigan.htm.

Foundation Center Cooperating Collections: Internet addresses

Alpena – Alpena County Library	http://www.alpenalibrary.org/special/grantseeking/grantseeking.html
Ann Arbor – U of M Graduate Library	http://guides.lib.umich.edu/grants
Battle Creek – Nonprofit Alliance Collections	http://www.willard.lib.mi.us/#
Detroit – Wayne State Purdy/Kresge Library	http://www.lib.wayne.edu/resources/guides/guide.php?id=29
East Lansing – MSU Main Library Reference	http://staff.lib.msu.edu/harris23/grants/index.htm
Farmington Hills – Community Library	http://www.farmlib.org/grants.html
Flint – U of M Flint Thompson Library	http://www.umflint.edu/library/
Fremont Area District Library	http://fremontlibrary.net/nonprofit.html
Grand Rapids – Public Library Reference Dept.	http://www.grpl.org
Kalamazoo – Public Library	http://www.kpl.gov/
Marquette – Peter White Public Library	http://www.uproc.lib.mi.us/pwpl/resources/foundation-center.html
Mason County – District Library	http://www.masoncounty.lib.mi.us/
Petoskey – Public Library	http://www.petoskeylibrary.org/inside.phtml?catid=105
Portage Lake – District Library	http://www.pldl.org/
Romeo – District Library	http://www.macomb.lib.mi.us/romeo/
Saginaw – Hoyt Public Library	http://www.saginawlibrary.org/your-library/grant-resource-center
Sault Ste. Marie – LSSU Library	http://www.lssu.edu/library/Grants.php
Traverse City – Area District Library	http://www.tadl.org/

Using Environmental / Economic Development Programs in Commercial Flood Acquisition, Relocation, and Infrastructure Mitigation Projects*

***NOTE:** A number of Federal or state administered environmental and economic development programs could possibly be used in concert with other funding sources to develop a funding "package" for implementing hazard mitigation projects. Such a project would undoubtedly be multi-objective in nature. That is, the purpose of the project would include not only hazard vulnerability reduction, but also enhancement of the environment or the community's economic development posture. When assembling such a funding "package", it is important to be flexible and creative. Projects that achieve more than one objective are almost always more desirable and beneficial than are projects that simply achieve a reduction in the community's hazard vulnerability. Although they are more difficult and take longer to implement, multi-objective projects and partnerships can help build lasting bridges between governmental agencies and between government and the private sector. Those bridges, in turn, can lead to enhanced coordination and cooperation in future community endeavors, and better integration of hazard mitigation principles and practices in day-to-day public and private sector activities.

Examples of possible commercial flood acquisition/relocation and/or infrastructure mitigation projects might include:

- Strengthening infrastructure that services commercial and industrial areas to prevent failure and loss of critical services.
- Creating new business sites so that existing businesses in the floodplain can be more easily relocated to less hazardous areas within the community.
- Cleaning up "brownfields" and making them into productive business sites so that businesses in the floodplain or other hazardous areas can relocate to them.
- Floodproofing or elevating existing businesses to prevent flood-related damage and negative economic impacts for the community.
- Stabilizing river / stream banks and road crossings to prevent sedimentation, reduce flood potential, and prevent the loss of roadway or other community infrastructure due to collapse from flooding.

- Constructing wetlands and retention / detention basins to manage stormwater and create wildlife habitat and environmental conservation areas.
- Stabilizing the Great Lakes shoreline property to prevent erosion, sedimentation, and possible physical damage to commercial and residential structures.
- Acquiring and demolishing waterfront structures and then using the site for other, more appropriate uses such as park and recreation land or less vulnerable commercial activities.

(See the MDEQ Clean Michigan Initiative web site for a listing of implemented multi-objective projects that have a mitigation component. Address: http://www.michigan.gov/deq/0,1607,7-135-3307_31116---,00.html.)

CFDA
The Catalog of Federal Domestic Assistance

Developing And Writing Grant Proposals

PART ONE: DEVELOPING A GRANT PROPOSAL

Preparation
A successful grant proposal is one that is well-prepared, thoughtfully planned, and concisely packaged. The potential applicant should become familiar with all of the pertinent program criteria related to the Catalog program from which assistance is sought. Refer to the information contact person listed in the Catalog program description before developing a proposal to obtain information such as whether funding is available, when applicable deadlines occur, and the process used by the grantor agency for accepting applications. Applicants should remember that the basic requirements, application forms, information and procedures vary with the Federal agency making the grant award.

Individuals without prior grant proposal writing experience may find it useful to attend a grantsmanship workshop. A workshop can amplify the basic information presented here. Applicants interested in additional readings on grantsmanship and proposal development should consult the references listed at the end of this section and explore other library resources.

INITIAL PROPOSAL DEVELOPMENT

Developing Ideas for the Proposal
When developing an idea for a proposal it is important to determine if the idea has been considered in the applicant's locality or State. A careful check should be made with legislators and area government agencies and related public and private agencies which may currently have grant awards or contracts to do similar work. If a similar program already exists, the applicant may need to reconsider submitting the proposed project, particularly if duplication of effort is perceived. If significant differences or improvements in the proposed project's goals can be clearly established, it may be worthwhile to pursue Federal assistance.

Community Support
Community support for most proposals is essential. Once proposal summary is developed, look for individuals or groups representing academic, political, professional, and lay organizations which may be willing to support the proposal in writing. The type and caliber of community support is critical in the initial and subsequent review phases. Numerous letters of support can be persuasive to a grantor agency. Do not overlook support from local government agencies and public officials. Letters of endorsement detailing exact areas of project sanction and

commitment are often requested as part of a proposal to a Federal agency. Several months may be required to develop letters of endorsement since something of value (e.g., buildings, staff, services) is sometimes negotiated between the parties involved.

Many agencies require, in writing, affiliation agreements (a mutual agreement to share services between agencies) and building space commitments prior to either grant approval or award. A useful method of generating community support may be to hold meetings with the top decision makers in the community who would be concerned with the subject matter of the proposal. The forum for discussion may include a query into the merits of the proposal, development of a contract of support for the proposal, to generate data in support of the proposal, or development of a strategy to create proposal support from a large number of community groups.

Identification of a Funding Resource

A review of the Objectives and Uses and Use Restrictions sections of the Catalog program description can point out which programs might provide funding for an idea. Do not overlook the related programs as potential resources. Both the applicant and the grantor agency should have the same interests, intentions, and needs if a proposal is to be considered an acceptable candidate for funding.

Once a potential grantor agency is identified, call the contact telephone number identified in Information Contacts and ask for a grant application kit. Later, get to know some of the grantor agency personnel. Ask for suggestions, criticisms, and advice about the proposed project. In many cases, the more agency personnel know about the proposal, the better the chance of support and of an eventual favorable decision. Sometimes it is useful to send the proposal summary to a specific agency official in a separate cover letter, and ask for review and comment at the earliest possible convenience. Always check with the Federal agency to determine its preference if this approach is under consideration. If the review is unfavorable and differences cannot be resolved, ask the examining agency (official) to suggest another department or agency which may be interested in the proposal. A personal visit to the agency's regional office or headquarters is also important. A visit not only establishes face-to-face contact, but also may bring out some essential details about the proposal or help secure literature and references from the agency's library.

Federal agencies are required to report funding information as funds are approved, increased or decreased among projects within a given State depending on the type of required reporting. Also, consider reviewing the Federal Budget for the current and budget fiscal years to determine proposed dollar amounts for particular budget functions.

The applicant should carefully study the eligibility requirements for each Federal program under consideration (see the Applicant Eligibility section of the Catalog program description). The applicant may learn that he or she is required to provide services otherwise unintended such as a service to particular client groups, or involvement of specific institutions. It may necessitate the modification of the original concept in order for the project to be eligible for funding. Questions about eligibility should be discussed with the appropriate program officer.

Deadlines for submitting applications are often not negotiable. They are usually associated with strict timetables for agency review. Some programs have more than one application deadline during the fiscal year. Applicants should plan proposal development around the established deadlines.

Getting Organized to Write the Proposal

Throughout the proposal writing stage keep a notebook handy to write down ideas. Periodically, try to connect ideas by reviewing the notebook. Never throw away written ideas during the grant writing stage. Maintain a file labeled "Ideas" or by some other convenient title and review the ideas from time to time. The file should be easily accessible. The gathering of documents such as articles of incorporation, tax exemption certificates, and bylaws should be completed, if possible, before the writing begins.

REVIEW

Criticism
At some point, perhaps after the first or second draft is completed, seek out a neutral third party to review the proposal working draft for continuity, clarity and reasoning. Ask for constructive criticism at this point, rather than wait for the Federal grantor agency to volunteer this information during the review cycle. For example, has the writer made unsupported assumptions or used jargon or excessive language in the proposal?

Signature
Most proposals are made to institutions rather than individuals. Often signatures of chief administrative officials are required. Check to make sure they are included in the proposal where appropriate.

Neatness
Proposals should be typed, collated, copied, and packaged correctly and neatly (according to agency instructions, if any). Each package should be inspected to ensure uniformity from cover to cover. Binding may require either clamps or hard covers. Check with the Federal agency to determine its preference. A neat, organized, and attractive proposal package can leave a positive impression with the reader about the proposal contents.

Mailing
A cover letter should always accompany a proposal. Standard U.S. Postal Service requirements apply unless otherwise indicated by the Federal agency. Make sure there is enough time for the proposals to reach their destinations. Otherwise, special arrangements may be necessary. Always coordinate such arrangements with the Federal grantor agency project office (the agency which will ultimately have the responsibility for the project), the grant office (the agency which will coordinate the grant review), and the contract office (the agency responsible for disbursement and grant award notices), if necessary.

PART TWO: WRITING THE GRANT PROPOSAL

The Basic Components of a Proposal
There are eight basic components to creating a solid proposal package: (1) the proposal summary; (2) introduction of organization; (3) the problem statement (or needs assessment); (4) project objectives; (5) project methods or design; (6) project evaluation; (7) future funding; and (8) the project budget. The following will provide an overview of these components.

The Proposal Summary: Outline of Project Goals
The proposal summary outlines the proposed project and should appear at the beginning of the proposal. It could be in the form of a cover letter or a separate page, but should definitely be brief -- no longer than two or three paragraphs. The summary would be most useful if it were prepared after the proposal has been developed in order to encompass all the key summary points necessary to communicate the objectives of the project. It is this document that becomes the cornerstone of your proposal, and the initial impression it gives will be critical to the success of your venture. In many cases, the summary will be the first part of the proposal package seen by agency officials and very possibly could be the only part of the package that is carefully reviewed before the decision is made to consider the project any further.

The applicant must select a fundable project which can be supported in view of the local need. Alternatives, in the absence of Federal support, should be pointed out. The influence of the project both during and after the project period should be explained. The consequences of the project as a result of funding should be highlighted.

Introduction: Presenting a Credible Applicant or Organization
The applicant should gather data about its organization from all available sources. Most proposals require a description of an applicant's organization to describe its past and present operations. Some features to consider are:

- A brief biography of board members and key staff members.
- The organization's goals, philosophy, track record with other grantors, and any success stories.
- The data should be relevant to the goals of the Federal grantor agency and should establish the applicant's credibility.

The Problem Statement: Stating the Purpose at Hand
The problem statement (or needs assessment) is a key element of a proposal that makes a clear, concise, and well-supported statement of the problem to be addressed. The best way to collect information about the problem is to conduct and document both a formal and informal needs assessment for a program in the target or service area. The information provided should be both factual and directly related to the problem addressed by the proposal. Areas to document are:

- The purpose for developing the proposal.
- The beneficiaries -- who are they and how will they benefit.
- The social and economic costs to be affected.
- The nature of the problem (provide as much hard evidence as possible).
- How the applicant organization came to realize the problem exists, and what is currently being done about the problem.
- The remaining alternatives available when funding has been exhausted. Explain what will happen to the project and the impending implications.
- Most importantly, the specific manner through which problems might be solved. Review the resources needed, considering how they will be used and to what end.

There is a considerable body of literature on the exact assessment techniques to be used. Any local, regional, or State government planning office, or local university offering course work in planning and evaluation techniques should be able to provide excellent background references. Types of data that may be collected include: historical, geographic, quantitative, factual, statistical, and philosophical information, as well as studies completed by colleges, and literature searches from public or university libraries. Local colleges or universities which have a department or section related to the proposal topic may help determine if there is interest in developing a student or faculty project to conduct a needs assessment. It may be helpful to include examples of the findings for highlighting in the proposal.

Project Objectives: Goals and Desired Outcome
Program objectives refer to specific activities in a proposal. It is necessary to identify all objectives related to the goals to be reached, and the methods to be employed to achieve the stated objectives. Consider quantities or things measurable and refer to a problem statement and the outcome of proposed activities when developing a well-stated objective. The figures used should be verifiable. Remember, if the proposal is funded, the stated objectives will probably be used to evaluate program progress, so be realistic. There is literature available to help identify and write program objectives.

Program Methods and Program Design: A Plan of Action
The program design refers to how the project is expected to work and solve the stated problem. Sketch out the following:

- The activities to occur along with the related resources and staff needed to operate the project (inputs).
- A flow chart of the organizational features of the project. Describe how the parts interrelate, where personnel will be needed, and what they are expected to do. Identify the kinds of facilities, transportation, and support services required (throughputs).

- Explain what will be achieved through 1 and 2 above (outputs); i.e., plan for measurable results. Project staff may be required to produce evidence of program performance through an examination of stated objectives during either a site visit by the Federal grantor agency and or grant reviews which may involve peer review committees.
- It may be useful to devise a diagram of the program design. For example, draw a three column block. Each column is headed by one of the parts (inputs, throughputs and outputs), and on the left (next to the first column) specific program features should be identified (i.e., implementation, staffing, procurement, and systems development). In the grid, specify something about the program design, for example, assume the first column is labeled inputs and the first row is labeled staff. On the grid one might specify under inputs five nurses to operate a child care unit. The throughput might be to maintain charts, counsel the children, and set up a daily routine; outputs might be to discharge 25 healthy children per week. This type of procedure will help to conceptualize both the scope and detail of the project.
- Wherever possible, justify in the narrative the course of action taken. The most economical method should be used that does not compromise or sacrifice project quality. The financial expenses associated with performance of the project will later become points of negotiation with the Federal program staff. If everything is not carefully justified in writing in the proposal, after negotiation with the Federal grantor agencies, the approved project may resemble less of the original concept. Carefully consider the pressures of the proposed implementation, that is, the time and money needed to acquire each part of the plan. A Program Evaluation and Review Technique (PERT) chart could be useful and supportive in justifying some proposals.
- Highlight the innovative features of the proposal which could be considered distinct from other proposals under consideration.
- Whenever possible, use appendices to provide details, supplementary data, references, and information requiring in-depth analysis. These types of data, although supportive of the proposal, if included in the body of the design, could detract from its readability. Appendices provide the proposal reader with immediate access to details if and when clarification of an idea, sequence or conclusion is required. Time tables, work plans, schedules, activities, methodologies, legal papers, personal vitae, letters of support, and endorsements are examples of appendices.

Evaluation: Product and Process Analysis

The evaluation component is two-fold: (1) product evaluation; and (2) process evaluation. Product evaluation addresses results that can be attributed to the project, as well as the extent to which the project has satisfied its desired objectives. Process evaluation addresses how the project was conducted, in terms of consistency with the stated plan of action and the effectiveness of the various activities within the plan.

Most Federal agencies now require some form of program evaluation among grantees. The requirements of the proposed project should be explored carefully. Evaluations may be conducted by an internal staff member, an evaluation firm or both. The applicant should state the amount of time needed to evaluate, how the feedback will be distributed among the proposed staff, and a schedule for review and comment for this type of communication. Evaluation designs may start at the beginning, middle or end of a project, but the applicant should specify a start-up time. It is practical to submit an evaluation design at the start of a project for two reasons:

- Convincing evaluations require the collection of appropriate data before and during program operations; and,
- If the evaluation design cannot be prepared at the outset then a critical review of the program design may be advisable.

Even if the evaluation design has to be revised as the project progresses, it is much easier and cheaper to modify a good design. If the problem is not well defined and carefully analyzed for cause and effect relationships then a good evaluation design may be difficult to achieve. Sometimes a pilot study is needed to begin the identification of facts and relationships. Often a thorough literature search may be sufficient.

Evaluation requires both coordination and agreement among program decision makers (if known). Above all, the Federal grantor agency's requirements should be highlighted in the evaluation design. Also, Federal grantor agencies may require specific evaluation techniques such as designated data formats (an existing information

collection system) or they may offer financial inducements for voluntary participation in a national evaluation study. The applicant should ask specifically about these points. Also, consult the Criteria For Selecting Proposals section of the Catalog program description to determine the exact evaluation methods to be required for the program if funded.

Future Funding: Long-Term Project Planning
Describe a plan for continuation beyond the grant period, and/or the availability of other resources necessary to implement the grant. Discuss maintenance and future program funding if program is for construction activity. Account for other needed expenditures if program includes purchase of equipment.

The Proposal Budget: Planning the Budget
Funding levels in Federal assistance programs change yearly. It is useful to review the appropriations over the past several years to try to project future funding levels (see the Financial Information provided by the Catalog of Federal Domestic Assistance materials).

However, it is safer to never anticipate that the income from the grant will be the sole support for the project. This consideration should be given to the overall budget requirements, and in particular, to budget line items most subject to inflationary pressures. Restraint is important in determining inflationary cost projections (avoid padding budget line items), but attempt to anticipate possible future increases.

Some vulnerable budget areas are: utilities, rental of buildings and equipment, salary increases, food, telephones, insurance, and transportation. Budget adjustments are sometimes made after the grant award, but this can be a lengthy process. Be certain that implementation, continuation and phase-down costs can be met. Consider costs associated with leases, evaluation systems, hard/soft match requirements, audits, development, implementation and maintenance of information and accounting systems, and other long-term financial commitments.

A well-prepared budget justifies all expenses and is consistent with the proposal narrative. Some areas in need of an evaluation for consistency are: (1) the salaries in the proposal in relation to those of the applicant organization should be similar; (2) if new staff persons are being hired, additional space and equipment should be considered, as necessary; (3) if the budget calls for an equipment purchase, it should be the type allowed by the grantor agency; (4) if additional space is rented, the increase in insurance should be supported; (5) if an indirect cost rate applies to the proposal, the division between direct and indirect costs should not be in conflict, and the aggregate budget totals should refer directly to the approved formula; and (6) if matching costs are required, the contributions to the matching fund should be taken out of the budget unless otherwise specified in the application instructions.

It is very important to become familiar with Government-wide circular requirements. The Catalog of Federal Domestic Assistance identifies in its program description section (as information is provided from the agencies) the particular circulars applicable to a Federal program, and summarizes the coordination of Executive Order 12372, "Intergovernmental Review of Programs" requirements in an appendix. The applicant should thoroughly review the appropriate circulars since they are essential in determining items such as cost principles and conforming to Government guidelines for Federal domestic assistance.

GUIDELINES AND LITERATURE

United States Government Manual
Superintendent of Documents
U.S. Government Printing Office
Washington, DC 20402

OMB Circular Nos. A-87, A-102, A-110, and A-133, and Executive Order 12372:
Publications Office
Office of Administration

Room 2200, 725 Seventeenth Street, NW.
Washington, DC 20503

Government Printing Office (GPO) Resources
The government documents identified above as available from the GPO can be requested (supply the necessary identifying information) by writing to:

Superintendent of Documents
Government Printing Office
Washington, DC 20402

Regional and Federal Depository Libraries

Regional libraries can arrange for copies of Government documents through an interlibrary loan. All Federal Depository Libraries will receive copies of the Catalog directly. A list of depository and regional libraries is available by writing: Chief, Library Division, Superintendent of Documents, Stop SLL, Washington, DC 20402.

STATE AGENCY MITIGATION FUNDING PROGRAMS

STATE AGENCY MITIGATION FUNDING PROGRAMS

Funding Sources for Hazard-Specific Measures	Drought	Earthquake	Extreme Temperatures	Wildfire	Dam Failure	Riverine Flooding	Great Lakes Shoreline Flooding	Subsidence	Hail	Lightning	Severe Wind	Tornadoes	Ice and Sleet Storms	Snowstorms	FINANCIAL ASSISTANCE	TECHNICAL ASSISTANCE
MICHIGAN DEPARTMENT OF AGRICULTURE																
Conservation Reserve Enhancement Program						X					X				X	X
Intercounty Drain Program (available to drain commissioners only)					X	X										X
MICHIGAN DEPT. OF ENVIRONMENTAL QUALITY																
Coastal Management Program							X								X	X
Michigan Great Lakes Protection Fund							X								X	
State Revolving Fund (Loan)						X									X	
Wetland Program Development (also see 66.461 in CFDA)						X	X								X	
MICHIGAN DEPT. OF NATURAL RESOURCES																
Land & Water Conservation Fund						X	X								X	
Michigan Habitat Improvement Fund Project Grants						X									X	
Michigan Natural Resources Trust Fund				X		X									X	
Michigan Volunteer Fire Assistance				X											X	
Recreational Trails Program Grants						X	X								X	
Community Forestry Program											X	X	X		X	X
MICHIGAN DEPARTMENT OF STATE POLICE																
Emergency Management Performance Grants (also see 97.042 in CFDA)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Flood Mitigation Assistance (also see 97.029 in CFDA)						X	X								X	
Hazard Mitigation Grant Program (also see 97.039 in CFDA)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Federal Disaster Assistance to Individuals and Households in Presidential Declared Disaster Areas (also see 97.048 in CFDA)		X		X		X	X	X			X	X			X	
Presidential Declared Disaster Assistance - Disaster Housing Operations For Individuals And Households (also see 97.049 in CFDA)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Presidential Declared Disaster Assistance To Individuals And Households - Other Needs (also see 97.050 in CFDA)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Disaster Grants-Public Assistance (Presidentially Declared Disasters) (also see 97.036 in CFDA)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Pre-Disaster Mitigation (also see 97.047 in CFDA)			X	X		X	X				X	X			X	
Severe Loss Repetitive Program (also see 97.110 in CFDA)						X	X								X	
Repetitive Flood Claims (also see 97.092 in CFDA)						X	X								X	
MICHIGAN DEPARTMENT OF TRANSPORTATION																
Transportation Economic Development Fund						X	X								X	
MICHIGAN ECONOMIC DEVELOPMENT CORP																
Community Development Block Grant Program (also see 14.218,14.219, 14.228 in CFDA)						X	X								X	
Urban Land Assembly						X	X								X	
MICHIGAN STATE HOUSING DEVELOPMENT AUTHORITY																
CDBG Housing Resource Fund (Inc HOME) (also see 14.239 in CFDA)						X	X		X		X	X			X	
Home/Property Improvement Loans						X	X		X		X	X			X	
MICHIGAN DEPARTMENT OF TREASURY																
Michigan Finance Authority-Local Gov't Loan Program	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Michigan Finance Authority-State Aid Note Program	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	

FEDERAL AGENCY MITIGATION FUNDING PROGRAMS (FROM THE CATALOG OF FEDERAL DOMESTIC ASSISTANCE)

Catalog of Federal Domestic Assistance
Index of Agencies

Agency Code	Agency
10	U.S. Department of Agriculture
11	U.S. Department of Commerce
12	U.S. Department of Defense
14	U.S. Department of Housing and Urban Development
15	U.S. Department of the Interior
47	National Science Foundation
59	Small Business Administration
66	U.S. Environmental Protection Agency
81	U.S. Department of Energy
97	Department of Homeland Security

FEDERAL HAZARD MITIGATION FUNDING SOURCES

Funding Sources for Hazard-Specific Measures																
10.054 Emergency Conservation Program	X					X					X	X			X	
10.069 Conservation Reserve Program						X					X	X			X	X
10.072 Wetlands Reserve Program						X	X								X	X
10.202 Cooperative Forestry Research				X							X	X			X	
10.410 Very Low to Moderate Income Housing Loans			X	X		X	X	X	X	X	X	X			X	
10.417 Very Low Income Housing Repair Loans/ Grants			X	X		X	X	X	X	X	X	X			X	
10.652 Forestry Research						X	X				X	X			X	
10.664 Cooperative Forestry Assistance				X											X	
10.760 Water & Waste Disposal Sys. for Rural Comm.						X	X								X	
10.763 Emergency Community Water Assistance Grants	X					X	X								X	
10.766 Community Facilities Loans & Grants	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
10.768 Business and Industry Loans	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
10.770 Water/ Waste Disposal Loans/ Grants						X	X								X	
10.773 Rural Business Opportunity Grants						X	X								X	
10.850 Rural Electrification Loans and Loan Guarntees										X	X	X	X	X	X	
10.901 Resource Conservation and Development	X	X	X	X		X	X									X
10.902 Soil and Water Conservation	X	X	X	X		X	X									X
10.904 Watershed Protection and Flood Prevention					X	X	X								X	X
10.913 Farm and Ranch Land Protection Program						X	X								X	
10.914 Wildlife Habitat Incentive Program						X	X								X	
11.300 Investments for Public Works and Economic Development Facilities					X	X	X								X	
11.303 Economic Development Technical Assistance						X	X								X	X
11.307 Economic Adjustment Assistance					X	X	X				X	X			X	
11.419 Coastal Zone Mgmt. Administration Awards							X									X
11.462 Hydrologic Research	X				X	X	X								X	
11.463 Habitat Conservation							X								X	
11.478 Center for Coastal Ocean Research Coastal Ocean Prgrm							X								X	
12.101 Beach Erosion Control Projects							X								X	
12.102 Emergency Rehabilitation of Flood Control Works or Federally Authorized Coastal Protection Works					X	X	X								X	
12.103 Emergency Operations Flood Response & Post-Flood Response					X	X	X								X	
12.104 Flood Plain Management Services					X	X	X									X
12.105 Protection of Essential Highways, Highway Bridge Approaches, and Public Works					X	X	X								X	
12.106 Flood Control Projects					X	X	X								X	
12.108 Snagging and Clearing for Flood Control					X	X	X								X	
12.109 Protection, Clearing and Straightening Channels						X	X								X	
12.111 Emergency Advance Measures for Flood Protection					X	X	X								X	
14.218 Community Development Block Grants/ Entitlement Grants	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
14.228 Community Development Block Grants-State's Program	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
14.239 HOME Investment Partnerships Program						X	X		X	X	X	X			X	
15.623 North American Wetlands Conservation Fund						X	X								X	
15.904 Historic Preservation Fund Grants-In-Aid						X	X	X	X	X	X	X	X	X		X
15.916 Outdoor Recreation-Acquisition, Development and Planning (Land and Water Conservation Fund Grants)						X	X								X	

FEDERAL HAZARD MITIGATION FUNDING SOURCES (CONT.)

Funding Sources for Hazard-Specific Measures	Drought	Earthquake	Extreme	Wildfire	Dam Failure	Riverine Flooding	Great Lakes Shoreline	Subsidence	Hail	Lightning	Severe Wind	Tornadoes	Ice and Sleet	Snowstorms	FINANCIAL ASSISTANCE	TECHNICAL ASSISTANCE
15.918 Disposal of Federal Surplus Real Property for Parks, Recreation, and Historic Monuments						X	X									
15.921 Rivers, Trails, and Conservation Assistance						X	X									X
47.041 Engineering Grants	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
59.008 Disaster Assistance Loans		X		X		X	X	X	X	X	X	X	X	X	X	
66.461 Regional Wetlands Program Development Grants						X	X								X	
66.469 Great Lakes Program							X								X	
81.042 Weatherization Assistance for Low-Income Persons			X												X	
97.018 National Fire Academy Training Assistance				X												X
97.022 Flood Insurance						X	X									X
97.023 Community Assistance Program - State Support Services Element (NFIP)						X	X									X
97.024 Emergency Food and Shelter National Board Program	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
97.026 Emergency Management Institute-Training Assistance	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X
97.028 Emergency Management Institute-Resident Education Program	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X
97.029 Flood Mitigation Assistance						X	X								X	
97.030 Community Disaster Loans	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
97.031 Cora Brown Fund	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
97.036 Disaster Grants - Public Assistance (Presidentially Declared Disasters)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
97.039 Hazard Mitigation Grant Program	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
97.041 National Dam Safety Program					X											X
97.042 Emergency Management Performance Grants	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
97.044 Assistance to Firefighters Grant				X											X	
97.045 Cooperating Techincal Partners						X	X								X	
97.046 Fire Management Assistance Grant				X											X	
97.047 Pre-Disaster Mitigation		X		X		X	X	X			X	X			X	
97.048 Disaster Housing Assistance to Individuals and Households in Presidential Declared Disaster Areas	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
97.049 Presidential Declared Disaster Assistance - Disaster Housing Operations for Individuals and Housholds	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
97.050 Presidential Declared Disaster Assistance to Individual and Households - Other Needs	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
97.092 Repetitive Flood Claims						X	X								X	
97.109 Disaster Housing Assistance Grant	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
97.110 Severe Repetitive Loss Program						X	X								X	

Project Scoring Matrix and Prioritization Criteria for the HMGP / FMAP / PDMP

Mitigation Grant Programs Project Prioritization Scoring Matrix

Project	Is the Project Mitigation? Y/N	Does it Support the MHMP? Y/N	Is it an Eligible Project? Y/N	Other Available Funding Sources?	Consistent with MCCERCC Priorities for this Federal Disaster?	Complete Solution?	Long-term Solution?	Cost Effective?	Environmentally Sound?	Consistent with other initiatives?	Total Score
	If yes, continue	If yes, continue	If yes, continue	If no, continue	1-5	1-5	1-5	1-5	1-5	1-5	

RESPONSE KEY:
5 = Strongly Agree
4 = Agree
3 = Neither Agree or Disagree (Neutral)
2 = Disagree
1 = Strongly Disagree

Project Prioritization Criteria

A project will be evaluated based on the following criteria:

- The project demonstrates sound hazard mitigation techniques.
- The project is listed in the applicable local hazard mitigation plan.
- The project supports the Michigan Hazard Mitigation Plan.
- The project meets the required eligibility criteria.
- The project is suitable for funding under the HMGP / FMAP / PDMP rather than other funding programs.
- The project is consistent with the MCCERCC approved strategy for the federally-declared disaster (if applicable).
- The project completely or substantially solves the problem.
- The project provides a permanent or long-term solution.
- The project is likely to be cost-effective based on physical damages prevented.
- The project will not create negative environmental effects.
- The project is consistent with other projects, initiatives, and state agency priorities.
- Communities with the highest risk.
- Communities with the greatest number of repetitive loss properties.
- Communities with the greatest number of NFIP insured structures.
- Communities with the most intense development pressures.
- Communities with the largest increases in population and/or physical development.
- Communities that have the ability to successfully implement hazard mitigation projects within the required timeframes.
- Communities that have expressed interest in hazard mitigation activities.

Project Eligibility Criteria

FEMA considers a project eligible for HMGP / FMAP / PDMP funding only if the project:

- Conforms to the State Hazard Mitigation Plan.
- Conforms to environmental laws and regulations.
- Is cost-effective.
- Solves a problem independently or constitutes a functional portion of a solution.
- Cannot be funded by another program.
- The applicant community is a member, in good standing, of the NFIP (flood related projects only).

  *Note – technical study type projects may be eligible for funding if they are accompanied by a second project (phase II) for construction measures that are developed and determined eligible by the study project (phase I).

Eligible Project Types

Following is a list of potentially eligible project types as outlined in federal guidance (this list is not all inclusive):

- **Acquisition of real property** in a hazard area; **physical relocation of structures** from a hazard area.

- **Elevation of structures** in compliance with federal, state and local ordinances.
- **Retrofit of structures** – wet or dry floodproofing (according to local code / building standards, compliant with NFIP standards); high wind bracing; seismic strengthening of structures or their non-structural components; application of wildfire resistant materials; and structural fire safety measures.
- **Minor structural flood risk reduction measures** – debris basins; stormwater detention basins or infiltration wells; culvert upgrades; diversions; flapgates or floodgates; localized flood risk reduction system to protect critical facilities.
- **Vegetation management** – natural windbreaks; living snow fences; shoreline stabilization; natural stabilization; wildfire defensible space, etc.
- **Phase I or II design, engineering or feasibility study** for complex mitigation projects that are reasonably expected to be funded and implemented.

Explanation: Complete Solution
Approved projects should either completely solve a site-specific problem or be an element of a larger solution where there is assurance of project completion.

Explanation: Long-term Solution
Mitigation measures funded under the HMGP / FMAP / PDMP are intended to provide a long-term or permanent solution. Ideally, the measure would be effective for the life of the property being protected. (For example, erecting an emergency berm on a beach to prevent wave damage to structures is a short-term solution, as opposed to a long-term solution such as elevation or relocation of the structures.)

Explanation: Cost Effective
For a project to be considered cost effective, the benefits gained by completing the project must be greater than the cost of the project. Cost effectiveness should take into account the following:

- The cost to complete the project.
- The life of the project.
- Past damages that have resulted from the situation that will be mitigated as a result of the project.
- The frequency and extent of damage that is likely to occur if the project is not completed.
- Annual costs of maintaining the project.

Explanation: Environmental Effects
All HMGP / FMAP / PDMP projects must be in conformance with applicable environmental laws and regulations, including but not limited to:
- The National Environmental Policy Act.
- The National Historic Preservation Act.
- The Endangered Species Act.
- Executive Order 11988, Floodplain Management.
- Executive Order 11990, Protection of Wetlands.
- Executive Order 12898, Environmental Justice.

(Note: a project should not create an environmental problem or shift a hazard to a new location.)

Explanation: Consistent with Other Initiatives
HMGP / FMAP / PDMP projects should be complimentary to other mitigation projects, initiatives, and state agency priorities. At a minimum, projects should not undermine other identified mitigation priorities and activities.

Summary of Hazard Mitigation Grant Program (HMGP), Flood Mitigation Assistance Program (FMAP), Pre-Disaster Mitigation Program (PDMP), and Repetitive Flood Claims Program (RFCP) Project and Planning Grants Funded in Michigan

HMGP Projects

Federal Disaster #1028: 1994 Northern Michigan Deep Freeze
Federal Disaster #1128: 1996 East Michigan Tornado and Flooding
Federal Disaster #1181: 1997 Southeast Michigan Tornadoes and Flooding
Federal Disaster #1226: 1998 West Michigan Windstorm
Federal Disaster #1237: 1998 Detroit Area Windstorm
Federal Disaster #1346: 2000 Detroit Area Urban Flooding
Federal Disaster #1413: 2002 Central and Western Upper Peninsula Flooding
Federal Disaster #1527: 2004 Southern Michigan Severe Storms and Flooding
Federal Disaster #1777: 2008 Central Michigan Severe Storms and Flooding

FMAP Projects

Planning, Technical Assistance, and Project Grants Awarded During Fiscal Years 1996-2013

PDMP Projects

PDMP Planning and Project Grants Awarded During Fiscal Years 2002-2013

RFCP Projects

RFCP Project Grant Awarded During Fiscal Year 2006 and 2012

Hazard Mitigation Grant Program

The Hazard Mitigation Grant Program (HMGP) was created by Section 404 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act (PL 93-288, as amended). The HMGP provides funding for states and local communities to implement long-term hazard mitigation measures that reduce or eliminate risk to people and property from natural and technological hazards and their effects. Funding for Michigan's HMGP is made available following a federal Major Disaster Declaration in the state. The amount available to the State for HMGP projects is based on 15% of the federal funds expended on the Public and Individual Assistance programs for the disaster, with an option to increase that amount to 20% with an approved "enhanced" state mitigation plan in place. The objective of the HMGP is to protect lives and property and significantly reduce or eliminate future disaster expenditures.

HMGP grants can be awarded to eligible applicants throughout the state, regardless of the boundaries of the disaster declaration. In Michigan, eligible applicants include state agencies, local governments, certain private non-profit organizations, and Indian Tribes or authorized tribal organizations. After November 1, 2004, federal funds are available for up to 75% of eligible project costs ONLY for those applicants that have in place or are covered under an approved hazard mitigation plan that meets the requirements of the federal Disaster Mitigation Act (DMA) of 2000. The remainder of the cost for the project is the responsibility of the applicant.

The HMGP can be used to fund projects to protect either public or private property. Examples of the types of projects that can be funded by the HMGP include, but are not limited to:

- Structural retrofitting to reduce wind and water damage
- Acquisition and relocation or elevation of flood-prone structures
- Strengthening vulnerable components of public infrastructure and facilities
- Development of state or local standards to protect new and substantially improved structures from wind and water damage
- Certain hazard or disaster related educational initiatives.

Applicants must apply for the HMGP through the MSP/EMHSD. The MCCERCC will set priorities for the HMGP following a disaster declaration. Based on those priorities, notification of available funding will be made to appropriate entities / organizations. The MCCERCC will review and prioritize eligible applications. Selected formal project applications will then be submitted by the MSP/EMHSD to FEMA for final funding approval.

Following a disaster declaration, prospective applicants, if not notified of available HMGP funds, may want to contact their local office of emergency management to see if HMGP funds are available. For additional information about the HMGP contact Matt Schnepp, State Hazard Mitigation Officer, by phone at (517) 336-2040, facsimile at (517) 333-4987, or e-mail at schneppm1@michigan.gov.

Flood Mitigation Assistance Program

On September 23, 1994 President Clinton signed into law the Reigle Community Development and Regulatory Improvement Act, referred to as the National Flood Insurance Reform Act (NFIRA). The purpose of the NFIRA is to improve the financial condition of the National Flood Insurance Program (NFIP) and to reduce the federal expenditures for federal disaster assistance to flood damaged properties. With the passage of the NFIRA, Congress authorized the establishment of a federal grant program to provide financial assistance to states and local communities for flood mitigation planning and activities. (Note: Flood mitigation is defined as any action taken before, during or after a flood to permanently eliminate or reduce the long-term risk to human life and property.) FEMA

has designated this as the Flood Mitigation Assistance Program (FMAP). Under the FMAP, FEMA provides assistance to states and local communities for activities that will reduce the risk of flood damage to structures insurable under the NFIP.

The FMAP is a state administered, cost-sharing program through which the States and communities can receive grants for flood mitigation activities. FEMA encourages the State to assist the local community in prioritizing mitigation activities outlined in their hazard mitigation plan and to fund projects that will greatly reduce the risk of flood damage to buildings, manufactured homes and other NFIP-insurable structures. Mitigation of substantially damaged and repetitive loss structures is a high priority.

Mitigation measures under the FMAP are funded on a 75% federal / 25% non–federal basis. (Note: Unless by special appropriation of the Michigan Legislature, no state funding will be used for the 25% match. Contributions of other state agencies may be used as an in-kind contribution toward the 25% match.)

Applications for FMAP grants are made directly to FEMA via the federal E-Grants system. The MCCERCC reviews all of the applications received and prioritizes applications. FEMA makes final project selections and approvals. For additional information about the FMAP contact Matt Schnepp, State Hazard Mitigation Officer, by phone at (517) 336-2040, facsimile at (517) 333-4987, or e-mail at schneppm1@michigan.gov.

Pre-Disaster Mitigation Program

The Pre-Disaster Mitigation Program (PDMP) provides funding to states and local communities for cost-effective hazard mitigation activities that complement a comprehensive mitigation program and reduce injuries, loss of life, and damage and destruction of property. The PDMP was authorized by Section 203 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act, as amended by Section 102 of the Disaster Mitigation Act of 2000. The PDMP is an annually appropriated, nationally competitive grant program.

States, local communities, and Indian Tribes can receive grants for mitigation activities such as planning and the implementation of projects identified through the evaluation of natural hazards. FEMA will set priorities for each appropriation of the PDMP. Eligible activities for the PDMP may include:

- **Planning.** PDMP funds may be used to develop or update state, tribal, and local multi-hazard mitigation plans which meet the planning criteria outlined in 44 CFR Part 201, pursuant to Section 322 of the Stafford Act.

- **Mitigation Projects.** A mitigation project is any action that results in elimination or long-term reduction of damages to public or private property from natural hazards and may include:
  1) Property acquisition or relocation, consistent with the Hazard Mitigation Grant Program, as defined in 44 CFR, 206.434(d) and related guidance.
  2) Structural and non-structural retrofitting for wildfire, seismic, wind or flood hazards (elevation, storm shutters, hurricane clips).
  3) Minor structural hazard control or protection projects that may include vegetation management, stormwater management (culverts, floodgates, retention basins), or shoreline / landslide. (Major flood risk reduction projects such as dikes, levees, floodwalls, seawalls, groins, jetties, dams, beach nourishment, and waterway channelization are not eligible.)

Mitigation measures under the PDMP are funded on a 75% federal / 25% non–federal basis. (Note: Unless by special appropriation of the Michigan Legislature, no state funding will be used for the 25% match. Contributions of other state agencies may be used as an in-kind contribution toward the 25% match.) Grants to small and impoverished communities may receive a federal cost share of up to 90% of the total cost to implement eligible PDMP activities. Small and

impoverished communities must meet the following criteria: 1) be a rural community with population of 3,000 or less; 2) be economically disadvantaged, with residents having an average per capita annual income not exceeding 80% of national per capita income; 3) have a local unemployment rate that exceeds by one percentage point or more, the most recently reported average yearly national unemployment rate; and 4) must meet any other factors identified in the State Plan in which the community is located.)

Applications for PDMP grants are made directly to FEMA via the federal E-Grants system. The MCCERCC reviews all of the applications received and prioritizes applications. The MCCERCC priority order is a factor in the national competitive grant review and scoring process. FEMA makes final project selections and approvals. For additional information about the PDMP contact Matt Schnepp, State Hazard Mitigation Officer, by phone at (517) 336-2040, facsimile at (517) 333-4987, or e-mail at schneppm1@michigan.gov.

Repetitive Flood Claims Program

The Repetitive Flood Claims Program (RFCP) was created pursuant to Section 1323 of the National Flood Insurance Act of 1968, as amended by the Bunning-Bereuter-Blumenauer Flood Insurance Reform Act of 2004, with the goal of reducing flood damages to individual properties for which one or more claim payments for losses have been made under flood insurance coverage and that will result in the greatest savings to the National Flood Insurance Fund in the shortest period of time. The RFCP was eliminated from FEMA's HMA program in Fiscal Year 2013 but the program was left in this summary of funded mitigation projects to document the funds received in Michigan under this program in Fiscal Years 2006 and 2012. In Fiscal Year 2013, some components of the RFCP were migrated to the FMAP.

RFCP funds were only to mitigate structures located within a community that could not meet the cost share or management capacity requirements of the FMAP. Grants under the RFCP were funded at 100% federal share. The RFCP was an annually appropriated, nationally competitive grant program.

Eligible RFCP project activities included: 1) voluntary acquisition or elevation of qualifying structures, 2) dry floodproofing of qualifying non-residential structures, and 3) minor localized flood risk reduction projects that protect qualifying structures.

Applications for RFCP grants were made directly to FEMA via the federal E-Grants system. FEMA made final project selections and approvals.

The tables on the following pages demonstrate that FEMA's various HMA programs have been successfully used to fund a wide variety of mitigation measures in Michigan – ranging from small, localized measures up to and including statewide initiatives:

Please note that most dollar amounts in the following tables represent complete grant totals. However, in cases where a grant was still active at the time of this writing, the amounts indicated in the tables represent projected amounts from the approved grant application.

Hazard Mitigation Grant Program: Disaster #1028, Underground Freeze, 12/93-5/94

Applicant	County	Application #	Project	Federal Investment	Local Investment	Total Investment
Village of South Range	Houghton	1028.001	4th Street watermain/service replacements	$86,642	$28,880	$115,522
Village of Boyne Falls	Charlevoix	1028.002	Railroad Street watermain replacement	$44,991	$14,996	$59,987
City of Escanaba	Delta	1028.003	Sewer freeze protection - various locations	$9,432	$3,143	$12,575
Village of Lake Linden	Houghton	1028.005	Osceola/Pine Street watermain replacements	$48,630	$16,209	$64,839
City of Ironwood	Gogebic	1028.007	Cherry Place water main replacement	$66,810	$22,270	$89,080
City of Ironwood	Gogebic	1028.008	Rowe Street watermain/service replacements	$22,354	$7,450	$29,804
City of Ironwood	Gogebic	1028.009	Bonnie Street sewer insulation	$4,380	$1,460	$5,840
City of Ironwood	Gogebic	1028.01	Bundy Street sewer insulation	$4,490	$1,495	$5,985
City of Ishpeming	Marquette	1028.011	Willow Street water line improvements	$18,037	$6,011	$24,048
City of Ishpeming	Marquette	1028.012	Bessemer/Iron Street water line improvement	$57,570	$19,188	$76,758
City of Ishpeming	Marquette	1028.013	Davis Street water line improvement	$71,985	$23,994	$95,979
City of Ishpeming	Marquette	1028.014	Elm Street water line improvement	$47,324	$15,773	$63,097
City of Marquette	Marquette	1028.015	Pine Street/Kaye Avenue/Russell Street water/sewer replacement	$50,200	$350,834	$401,034

Hazard Mitigation Grant Program: Disaster #1028, Underground Freeze, 12/93-5/94 (cont.)

Applicant	County	Application #	Project	Federal Investment	Local Investment	Total Investment
City of Boyne City	Charlevoix	1028.016	Clarke Street watermain replacement	$4,212	$1,404	$5,616
City of Boyne City	Charlevoix	1028.017	Elm Street sewermain replacement	$19,500	$6,499	$25,999
City of Boyne City	Charlevoix	1028.018	Clarke Street sewermain replacement	$3,039	$1,011	$4,050
City of Boyne City	Charlevoix	1028.019	Bailey Street watermain replacement	$18,605	$6,201	$24,806
City of Boyne City	Charlevoix	1028.02	West/Trent Street watermain replacement	$22,223	$7,406	$29,629
			Total for Disaster #1028:	**$600,424**	**$534,224**	**$1,134,648**

Hazard Mitigation Grant Program: Disaster #1128, Tornado and Flooding, 6/21-23/96

Applicant	County	Application #	Project	Federal Investment	Local Investment	Total Investment
Flint River Dike and Erosion Control Board	Saginaw	1128.002	Reconstruct sections of Flint River Dike	$90,000	$51,820	$141,820
City of Marlette	Sanilac	1128.003	Construct retention pond near William Little Subdivision	$371,250	$238,800	$610,050
Michigan Department of Agriculture & Rural Devel.	(State Agency)	1128.004	Digitize soil data for seven county area	$146,245	$95,436	$241,681
Bay County Drain Commission	Bay	1128.005	Garfield Subdivision area flood relief project	$66,729	$22,243	$88,972
Bridgeport Charter Twp.	Saginaw	1128.006	Repair bank and install rip-rap along Cass River	$26,081	$8,919	$35,000
Midland County Drain Commission	Midland	1128.007	Reconstruct Lingle Drain outlet	$36,000	$17,874	$53,874
Saginaw County Road Commission	Saginaw	1128.008	River Road bank stabilization	$172,500	$204,137	$376,637
Bay Area Family "Y" Center	Bay	1128.009	Elevate 2 boiler control boxes in basement	$5,700	$1,900	$7,600
Saginaw County Road Commission	Saginaw	1128.010	Dixie Highway shoulder stabilization	$7,500	$3,763	$11,263
City of Frankenmuth	Tuscola	1128.012	Install sheetpile wall and rehabilitate/stabilize bank of Cass River	$142,500	$65,249	$207,749
City of Bay City	Bay	1128.013	Floodproof city wastewater treatment plant	$389,912	$129,971	$519,883
Bay County Road Commission	Bay	1128.014	Shoulder stabilization on Youngs Ditch Road	$92,954	$30,985	$123,939

Hazard Mitigation Grant Program: Disaster #1128, Tornado and Flooding, 6/21-23/96 (cont.)

Applicant	County	Application #	Project	Federal Investment	Local Investment	Total Investment
Bay County Road Commission	Bay	1128.015	Shoulder stabilization for Kinney Road	$16,227	$5,408	$21,635
Tuscola County Drain Commission	Tuscola	1128.016	Coleman Drainage District improvements	$123,500	$65,389	$188,889
City of Midland	Midland	1128.020	Acquisition and relocation of business out of Tittabawassee River floodplain **(Project cancelled by company)**	$11,250	$3,750.00	$15,000
			Total for Disaster #1128:	**$1,698,348**	**$945,644**	**$2,643,992**

Hazard Mitigation Grant Program: Disaster #1181, Tornado and Flooding, 7/2/97

Applicant	County	Application #	Project	Federal Investment	Local Investment	Total Investment
Michigan Department of Agriculture & Rural Devel.	(Statewide)	1181.001	Digitize soil survey data for four county area	$112,500	$88,672	$201,172
City of Hamtramck	Wayne	1181.003	Install warning siren	$15,064	$5,022	$20,086
Genesee County	Genesee	1181.004	Install additional radio activated warning notifiers	$4,890	$1,630	$6,520
City of River Rouge	Wayne	1181.005	Install early warning system	$9,375	$3,592	$12,967
Wayne County Emergency Management Division	Wayne	1181.006	Purchase and distribute NOAA weather radios to schools, hospitals and nursing homes	$15,737	$5,246	$20,983
Groveland Township	Oakland	1181.007	Install three warning sirens	$38,250	$12,750	$51,000
Macomb County	Macomb	1181.008	Install county Emergency Alert System	$10,481	$6,141	$16,622
City of Detroit Neighborhood City Halls	Wayne	1181.009	Implement long-term community outreach	$2,250	$757	$3,007
City of Plymouth	Wayne	1181.012	Install warning sirens	$9,750	$8,220	$17,970
Arenac County Emergency Management	Arenac	1181.013	Install early warning system	$45,000	$30,541	$75,541
Macomb County	Macomb	1181.014	Develop a family preparedness public information program	$4,144	$1,381	$5,525
Michigan Department of Natural Resources	(Statewide)	1181.015	Develop and deliver urban forestry educational program	$15,000	$16,237	$31,237
City of Flint	Genesee	1181.016	Acquire and relocate five flood prone houses in repetitive flood area	$237,702	$79,234	$316,936

Hazard Mitigation Grant Program: Disaster #1181, Tornado and Flooding, 7/2/97 (cont.)

Applicant	County	Application #	Project	Federal Investment	Local Investment	Total Investment
City of Flint	Genesee	1181.017	Acquire and relocate 16 floodprone houses in repetitive flood area	$192,862	$64,287	$257,150
City of Flint	Genesee	1181.018	Acquire and relocate eight floodprone houses in repetitive flood area	$359,785	$119,928	$479,714
Brownstown Charter Twp.	Wayne	1181.020	Elevate 12 floodprone homes	$136,125	$60,325	$196,450
Oakland County Radio Communications	Oakland	1181.024	Install wind braces to microwave dishes on radio towers	$10,125	$5,555	$15,680
Bridgeport Charter Twp.	Saginaw	1181.025	Remove log jam in river and rebuild/stabilize banks with rip-rap	$28,613	$9,537	$38,150
Ottawa County Drain Commission	Ottawa	1181.028	Bore/jack additional culvert under M-21(Rose Drain)	$235,525	$91,843	$327,368
Ottawa County Drain Commission	Ottawa	1181.029	Construct relief drain on existing stormwater basins	$30,000	$80,000	$110,000
Michigan State Housing Development Authority	(Statewide)	1181.030	Wind-proof 75-100 homes in the Detroit area	$7,335	$2,445	$9,780
Detroit Fire Department	Wayne	1181.032	Install warning siren on Cadillac Building	$13,875	$4,745	$18,620
City of Holland (in conjunction with MDARD)	Ottawa	1181.033	Purchase and remove two homes located in floodway	$108,750	$60,490	$169,240
Michigan Department of Environmental Quality	(Statewide)	1181.036	Digitize floodplain mapping of the Grand River	$29,262	$9,927	$39,189
City of Birmingham	Oakland	1181.042	Install ejector pumps, backflow preventers, or standpipes in flood prone houses	$211,392	$70,464	$281,856
Ottawa County	Ottawa	1181.043	Install NOAA weather radio transmitter for portions of Ottawa, Muskegon and Allegan Co.	$16,492	$17,689	$34,181
Grand Traverse County	Grand Traverse	1181.044	Phase I: study for area floodplain mapping; Phase II: acquisition / elevation of flood prone structures	$52,500	$17,500	$70,000

Hazard Mitigation Grant Program: Disaster #1181, Tornado and Flooding, 7/2/97 (cont.)

Applicant	County	Application #	Project	Federal Investment	Local Investment	Total Investment
City of Gibraltar	Wayne	1181.047	Elevate floodprone homes	$124,506	$41,502	$166,008
Village of Reese	Tuscola	1181.048	Acquire and remove two homes located in floodway	$153,961	$51,320	$205,281
Bay County Drain Commission	Bay	1181.050	Acquire and remove several floodprone homes	$609,005	$151	$609,156
City of Ishpeming	Marquette	1181.052	Insulate city water and sewer infrastructure to protect from ground freeze	$400,414	$133,441	$533,855
Tuscola County Drain Commission	Tuscola	1181.053	Construct flood relief drain in Village of Reese	$213,743	$71,248	$284,991
Antrim Conservation District	Antrim	1181.055	Safety upgrades for Cravens Pond Dam and Richardi Dam in Village of Bellaire	$276,938	$158,147	$435,085
			Total for Disaster #1181:	**$3,731,351**	**$1,329,969**	**$5,061,320**

Hazard Mitigation Grant Program Disaster: #1226, Thunderstorms and High Winds, 5/31/98

Applicant	County	Application #	Project	Federal Investment	Local Investment	Total Investment
Georgetown Charter Twp.	Ottawa	1226.001	Move existing warning sirens and add sirens to warning system	$48,000	$17,841	$65,841
Alpine Twp.	Kent	1226.003	Install three warning sirens (electronically operated by Emergency Dispatch)	$40,295	$13,432	$53,727
Orleans Twp.	Ionia	1226.004	Install warning sirens near two populated areas	$25,349	$8,450	$33,799
City of Coopersville	Ottawa	1226.005	Install early warning siren with generator; install two generators at existing sites	$14,419	$4,806	$19,225
City of Alma	Gratiot	1226.006	Install warning siren	$14,852	$6,317	$21,169
City of Ionia	Ionia	1226.007	Install four warning sirens	$51,870	$17,290	$69,160
City of Allen Park	Wayne	1226.008	Install four warning sirens	$48,416	$33,399	$81,815
City of Birmingham	Oakland	1226.009	Install two warning sirens	$32,594	$10,865	$43,459
City of Rochester Hills	Oakland	1226.01	Install two warning sirens	$22,755	$7,585	$30,340
City of Belding	Ionia	1226.011	Install three warning sirens	$13,404	$6,182	$19,586
Muskegon County Airport	Muskegon	1226.013	Modify roof ballast system of airport passenger terminal building	$6,592	$2,198	$8,790
Flint River Dike and Erosion Control Board	Saginaw	1226.015	Stump, tree, and debris removal; construction of offset earth dikes	$112,979	$37,659	$150,638

Hazard Mitigation Grant Program: Disaster #1226, Thunderstorms and High Winds, 5/31/98 (cont.)

Applicant	County	Application #	Project	Federal Investment	Local Investment	Total Investment
Tuscola County Drain Commission	Tuscola	1226.016	Study and implement flood mitigation measures for Moore Drain	$104,982	$34,994	$139,976
Mackinac County	Mackinac	1226.017	Install and house an existing generator at new shelter facility	$15,000	$17,669	$32,669
Monroe County Drain Commission	Monroe	1226.018	Modify, rebuild, retrofit existing intake structure	$32,462	$10,821	$43,283
City of Grand Haven	Ottawa	1226.019	Phase I Study: Mitigation of power source problems	$10,875	$3,625	$14,500
City of Grand Haven	Ottawa	1226.02	Rewire existing generators	$56,237	$18,746	$74,983
Village of Spring Lake	Ottawa	1226.021	Replace Village Hall roof with reinforced roof buttressed by support columns	$1,594	$531	$2,125
City of Birmingham	Oakland	1226.022	Install seawall along river at several businesses and offices	$67,210	$22,403	$89,613
Bay County Drain Commission	Bay	1226.025	Floodproof 36 floodprone houses (subject to 1226.034 study findings)	$264,415	$88,138	$352,553
City of Wyoming	Kent	1226.026	Replace bridge over creek in industrial park with improved design to reduce flood damage	$451,144	$150,381	$601,525
Flint River Dike and Erosion Control Board	Saginaw	1226.027	Create a retention basin by constructing a new dike and removing the old one	$150,000	$185,797	$335,797
Iosco County Drain Commission	Iosco	1226.028	Install rock rip-rap along banks of Crosby Road	$7,511	$2,503	$10,014
Huron County Drain Commission	Huron	1226.03	Drain reconstruction and flow diversion	$114,750	$101,540	$216,290
City of Birmingham	Oakland	1226.031	Purchase NOAA weather radios	$2,668	$889	$3,557

Hazard Mitigation Grant Program: Disaster #1226, Thunderstorms and High Winds, 5/31/98 (cont.)

Applicant	County	Application #	Project	Federal Investment	Local Investment	Total Investment
Isabella County	Isabella	1226.032	Install NOAA transmitter - communication system for severe weather alerts	$44,059	$14,685	$58,744
Michigan Department of Environmental Quality	(Statewide)	1226.033	Scan and store on disk all flood modeling since 1968 by NFIP, for future distribution	$14,560	$10,029	$24,590
Bay County Drain Commission	Bay	1226.034	Flood study and designs for projects 1226.024 and 1226.025	$39,499	$13,146	$52,645
Michigan Department of Environmental Quality	Ottawa	1226.037	Study for acquisition of floodprone homes project on Macatawa River (1226.044)	$80,540	$26,847	$107,386
City of Midland	Midland	1226.039	Acquire eight properties in the floodplain (8 properties proposed, only 1 was purchased)	$11,387	$3,795	$15,182
City of Gibraltar	Wayne	1226.04	Elevate floodprone structures	$51,744	$29,874	$81,618
City of Luna Pier	Monroe	1226.042	Elevate floodprone structures	$168,740	$56,247	$224,986
Clinton Charter Twp.	Macomb	1226.043	Acquire flood prone properties (project canceled by applicant)	$2,250	$750	$3,000
Ottawa County Parks and Recreation Commission	Ottawa	1226.044	Acquire and remove flood prone structures on the Macatawa River	$243,546	$81,182	$324,728
			Total for Disaster #1226:	**$2,366,697**	**$1,040,615**	**$3,407,312**

Hazard Mitigation Grant Program: Disaster #1237, Thunderstorms and High Winds, 7/21-22/98

Applicant	County	Application #	Project	Federal Investment	Local Investment	Total Investment
Otsego County RACES Radio Group	Otsego	1237.001	Purchase NOAA weather alert monitors	$1,575	$531	$2,106
City of Inkster	Wayne	1237.002	Install two warning sirens	$27,750	$12,150	$39,900
City of St. Clair Shores	Macomb	1237.003	Install four warning sirens	$27,750	$73,683	$101,433
VESSA	Kent	1237.004	Enhance early warning capability	$30,000	$10,159	$40,159
Antrim County	Antrim	1237.005	Purchase NOAA weather alert monitors	$9,320	$3,106	$12,426
Macomb County	Macomb	1237.009	Lightning protection-grounding, phasing	$26,100	$8,700	$34,800
Macomb County	Macomb	1237.010	Lightning protection-grounding, phasing	$7,395	$2,465	$9,860
City of Lowell	Kent	1237.014	Install two warning sirens; upgrade two existing sirens	$26,400	$8,800	$35,200
City of Wyoming	Kent	1237.015	Acquire five floodway properties	$280,224	$93,155	$373,379
			Total for Disaster #1237:	**$436,514**	**$212,749**	**$649,263**

Hazard Mitigation Grant Program: Disaster #1346, Urban Flooding, 9/10-11/00

Applicant	County	Application #	Project	Federal Investment	Local Investment	Total Investment
Ada Twp.	Kent	1346.538	Install six warning sirens	$81,375	$52,945	$134,320
Alcona County Road Commission	Alcona	1346.65	Replace undersized culverts with bridge	$180,000	$117,992	$297,992
Allegan County Drain Commission	Allegan	1346.71	Install flood walls and storm water pump	$256,923	$85,641	$342,564
Alpena County Road Commission	Alpena	1346.62	Culvert / bridge upgrade	$69,830	$23,277	$93,107
City of Alpena	Alpena	1346.43	Culvert upgrade	$82,500	$46,590	$129,090
City of Alpena	Alpena	1346.535	Install two warning sirens	$27,258	$9,125	$36,383
City of Alpena	Alpena	1346.6	Water recycling plant emergency backup generator	$187,500	$120,460	$307,960
Alpine Twp.	Kent	1346.529	Install warning siren	$13,500	$5,178	$18,678
Bay County Drain Commission	Bay	1346.89	Drainage improvements in Garfield Subdivision	$971,226	$323,742	$1,294,968
Blackman Charter Twp.	Jackson	1346.17	Portable generator for sewer	$22,422	$11,640	$34,062
Blackman Charter Twp.	Jackson	1346.540	Install four warning sirens	$54,375	$19,200	$73,575
Bloomfield Twp.	Oakland	1346.13	Franklin Branch Streambank Stabilization Project	$1,605,000	$949,503	$2,554,503
Bruce Twp. and Village of Romeo	Macomb	1346.528	Install four warning sirens	$54,375	$21,225	$75,600

Hazard Mitigation Grant Program: Disaster #1346, Urban Flooding, 9/10-11/00 (cont.)

Applicant	County	Application #	Project	Federal Investment	Local Investment	Total Investment
Charlevoix County Road Commission	Charlevoix	1346.67	Replace two culverts with box culvert	$167,045	$78,400	$245,445
Cheboygan County	Cheboygan	1346.9	Mullett Lake bank stabilization	$13,407	$4,469	$17,876
Chippewa County Road Commission	Chippewa	1346.81	Culvert and bank stabilization	$424,989	$141,663	$566,652
Village of Clinton	Lenawee	1346.33	Construct retention basin	$110,586	$36,862	$147,448
Commerce Township	Oakland	1346.59	Flood mitigation study	$102,097	$34,032	$136,130
City of Coopersville	Ottawa	1346.87	Culvert replacement and acquisition of one floodprone house	$414,756	$138,381	$553,138
Crawford County	Crawford	1346.503	NOAA weather alert radio distribution	$1,475	$492	$1,967
City of Crystal Falls	Iron	1346.27	North 6th Street stormwater conveyance	$64,285	$32,624	$96,909
Central Upper Peninsula Planning and Development	Upper Peninsula	1346.523	Develop hazard analyses and identify mitigation needs for six UP counties	$75,000	$26,332	$101,332
Daycroft Montessori School	Washtenaw	1346.56	Construct floodwall around school	$84,789	$28,263	$113,052
City of Dearborn Heights	Wayne	1346.511	Ecorse Creek warning sensor	$9,255	$3,095	$12,350
City of Dearborn Heights	Wayne	1346.522	Install two warning sirens, plus electrical hookup and remote activation	$24,443	$8,147	$32,590

Hazard Mitigation Grant Program: Disaster #1346, Urban Flooding, 9/10-11/00 (cont.)

Applicant	County	Application #	Project	Federal Investment	Local Investment	Total Investment
Dickinson County Emergency Services	Dickinson	1346.72	Floodproof Cornish Pump Museum	$14,918	$4,973	$19,890
City of Dowagiac	Cass	1346.526	Install three warning sirens	$40,875	$20,425	$61,300
City of Fennville	Allegan	1346.539	Install warning siren	$12,279	$4,093	$16,371
Flint River Dike and Erosion Control Board	Saginaw	1346.53	Complete Flint River flood risk reduction project	$1,845,000	$568,121	$2,413,121
City of Gaastra	Iron	1346.54	Relocate main sewer line and stabilize bank next to abandoned Baltic Mine Pit	$36,078	$12,026	$48,104
Genesee County Drain Commission	Genesee	1346.82	Floodproof Pumping Station No. 1 in Flint Twp.	$559,068	$186,356	$745,423
Genesee County Drain Commission	Genesee	1346.83	Elevate and floodproof manholes in Flint Twp.	$274,697	$91,566	$366,262
City of Grand Blanc	Genesee	1346.29	Bella Vista Subdivision drainage system	$553,252	$184,417	$737,670
City of Grand Blanc	Genesee	1346.30	Indian Hills Subdivision drainage system	$195,000	$65,205	$260,205
City of Grand Blanc	Genesee	1346.88	Acquire five floodprone homes; storm sewer upgrades	$1,230,050	$410,017	$1,640,067
City of Grand Rapids	Kent	1346.68	Plaster Creek flood mitigation	$571,658	$425,652	$997,310
Grand Traverse County	Grand Traverse	1346.502	NOAA weather alert radio distribution	$5,242	$1,747	$6,989
Gratiot County Road Commission	Gratiot	1346.77	Lakeside Drive culvert upgrade	$262,500	$121,512	$384,012

Hazard Mitigation Grant Program: Disaster #1346, Urban Flooding, 9/10-11/00 (cont.)

Applicant	County	Application #	Project	Federal Investment	Local Investment	Total Investment
Grand Traverse Bay Ottawa / Chippewa Indians	(Native American Tribe)	1346.536	Install warning siren	$13,875	$8,100	$21,975
City of Holland	Ottawa	1346.524	Install warning siren	$13,155	$6,145	$19,300
City of Hudsonville	Ottawa	1346.530	Install warning siren	$13,875	$6,547	$20,422
Iosco County Road Commission	Iosco	1346.76	Update undersized culvert and enlarge / deepen drainage channels	$60,000	$84,682	$144,682
Village of Kent City	Kent	1346.34	Upgrade undersized culvert and replace with box beam bridge	$257,627	$85,876	$343,503
City of Kentwood	Kent	1346.23	Ridgemoor Center flood mitigation (stormwater control)	$568,818	$189,606	$758,424
Livingston County Drain Commission	Livingston	1346.61	Flood mitigation study	$4,188	$1,396	$5,583
Livingston County Drain Commission	Livingston	1346.75	Acquisition and relocation of floodprone homes	$438,665	$146,222	$584,886
City of Luna Pier	Monroe	1346.504	Install permanent elevation benchmark monuments along Lake Erie	$16,539	$5,513	$22,052
Lyon Township	Oakland	1346.42	Stormwater drainage improvements	$255,715	$85,238	$340,953
Macomb County	Macomb	1346.506	Purchase weather alert radios	$15,000	$5,257	$20,257
Macomb County	Macomb	1346.507	Streambank and road crossing inventory (for Middle Branch of the Clinton River)	$22,493	$8,206	$30,699
Macomb County Emergency Management	Macomb	1346.51	Acquisition of 2 vacant parcels and acquisition/demolition of 4 homes	$571,673	$190,558	$762,231

Hazard Mitigation Grant Program: Disaster #1346, Urban Flooding, 9/10-11/00 (cont.)

Applicant	County	Application #	Project	Federal Investment	Local Investment	Total Investment
Macomb County Public Works Office	Macomb	1346.44	Upgrade two pumping stations	$225,000	$494,227	$719,227
Macomb Twp.	Macomb	1346.534	Install two warning sirens	$27,375	$20,725	$48,100
City of Manton	Wexford	1346.79	Floodproof wastewater treatment plant	$634,823	$211,608	$846,431
Marquette County Conservation District	Marquette	1346.38	Dam removal	$94,971	$31,657	$126,628
Michigan Association of Broadcasters	(Statewide)	1346.541	Emergency Alert System (EAS) upgrade	$54,525	$18,488	$73,013
Michigan Department of Environmental Quality	(Statewide)	1346.521	Develop floodplain management guidance document	$6,000	$2,000	$8,000
Michigan Department of Natural Resources	(Southern Michigan)	1346.517	Develop FIREWISE communities in Southern Michigan	$202,500	$102,452	$304,952
Michigan Department of Natural Resources	(Various Upper Peninsula Sites)	1346.537	Closing and capping abandoned mines	$193,518	$65,726	$259,244
Michigan Department of State Police/EMHSD	(Statewide)	1346.90	Administering consultant for statewide repetitive flood loss properties project	$194,796	$0	$194,796
Michigan Department of State Police/EMHSD	(Statewide)	1346.91	Construction costs (elevation or acquisition) for repetitive flood loss properties project	$754,034	$251,346	$1,005,379
Michigan Department of State Police/EMHSD	(Statewide)	1346.519	Produce and distribute emergency management educational materials	$15,000	$5,000	$20,000
Michigan Department of State Police/EMHSD	(Statewide)	1346.518	Develop and implement statewide mitigation marketing and public education program	$19,717	$0	$19,717
Michigan Department of State Police/EMHSD	(State Agency)	1346.516	Expand and enhance Geographic Information Systems (GIS) capabilities and products	$181,732	$60,577	$242,310

Hazard Mitigation Grant Program: Disaster #1346, Urban Flooding, 9/10-11/00 (cont.)

Applicant	County	Application #	Project	Federal Investment	Local Investment	Total Investment
Michigan Department of State Police/EMHSD	(Statewide)	1346.802	Develop hazard mitigation plans in all emergency management program jurisdictions	$2,033,313	$774,843	$2,808,156
Michigan Department of Transportation	Baraga	1346.45	Shoreline protection on US-41 at Red Rocks	$41,255	$13,752	$55,007
Michigan Department of Transportation	Keweenaw	1346.46	Upgrade culvert on M-26 at Jacob Falls	$112,500	$38,152	$150,652
Michigan Department of Transportation	Marquette	1346.47	Shoreline protection and stabilization of sand dunes on M-28	$168,750	$94,302	$263,052
Michigan Department of Transportation	Baraga	1346.48	Upgrade culverts at Alberta Ponds	$15,000	$8,695	$23,695
Michigan Department of Transportation	Gogebic	1346.49	Upgrade culvert on US-2 at Black River	$112,500	$172,497	$284,997
Michigan Department of Transportation	Mackinac	1346.50	Stabilize sand dune along US-2	$168,750	$72,335	$241,085
Michigan State University	Ingham	1346.11	Construct storm shelters (“safe rooms”) in the Spartan Child Development Center	$123,750	$41,250	$165,000
Michigan Technological University	Houghton	1346.501	Research on the development of a composite shear wall for resisting high wind loads	$34,500	$11,562	$46,062
City of Montague	Muskegon	1346.66	Purchase and remove a commercial structure from the floodplain	$251,331	$83,777	$335,108
Northwest County Drainage District	Tuscola	1346.543	Install automated weather station	$4,066	$1,355	$5,421
City of Novi	Oakland	1346.31	Upgrade undersized culvert	$69,706	$23,235	$92,941
Osceola County	Lake, Mason, Osceola	1346.510	Upgrade NOAA weather radio coverage in three county area	$60,000	$23,821	$83,821
Ottawa County Parks and Recreation Commission	Ottawa	1346.93	Purchase and remove a home along the Grand River	$187,500	$83,230	$270,730

Hazard Mitigation Grant Program: Disaster #1346, Urban Flooding, 9/10-11/00 (cont.)

Applicant	County	Application #	Project	Federal Investment	Local Investment	Total Investment
Ottawa County Road Commission	Ottawa	1346.60	Upgrade undersized culvert and stabilize with rip-rap	$82,500	$73,916	$156,416
Ottawa County	Ottawa	1346.505	Purchase and distribute NOAA weather radios	$12,000	$4,015	$16,015
City of Parchment	Kalamazoo	1346.52	Improve / upgrade stormwater collection system	$63,239	$21,080	$84,318
City of Port Huron	St. Clair	1346.10	Standby power for water treatment plant	$175,253	$58,418	$233,671
City of Portland	Ionia	1346.80	Bury power lines to prevent recurring outages	$207,620	$69,207	$276,827
Rich Intercounty Drainage District	Lapeer	1346.545	Install automated weather station	$4,066	$1,355	$5,421
City of Rose City	Ogemaw	1346.70	Upgrade undersized culvert	$150,000	$52,325	$202,325
Sebewaing River Drainage Board	Huron	1346.57	Construct Sebewaing River emergency floodway	$261,750	$109,590	$371,340
Shelby Twp.	Macomb	1346.532	Install four warning sirens	$48,375	$20,305	$68,680
South Branch Cass River Intercounty Drainage District	Sanilac	1346.544	Install automated weather station	$4,066	$1,355	$5,421
South Branch, Mill Creek Drainage District	St. Clair	1346.542	Install automated weather station	$4,066	$1,355	$5,421
City of Southgate	Oakland	1346.15	Construct sanitary relief sewer to reduce flooding	$100,211	$33,404	$133,614
Spring Lake Twp.	Ottawa	1346.531	Install two warning sirens	$27,375	$10,157	$37,532

Hazard Mitigation Grant Program: Disaster #1346, Urban Flooding, 9/10-11/00 (cont.)

Applicant	County	Application #	Project	Federal Investment	Local Investment	Total Investment
City of Standish	Arenac	1346.63	Install box culvert	$82,875	$57,424	$140,299
Statewide Services for the Hearing Impaired	Genesee	1346.514	Deaf elderly / deaf disabled early warning system	$29,704	$2,952	$32,656
City of Sturgis	St. Joseph	1346.64	Stormwater diversion project	$245,381	$81,794	$327,175
Village of Sunfield	Eaton	1346.74	Storm sewer upgrade	$225,000	$95,086	$320,086
Tuscola County Drain Commission	Tuscola	1346.18	Flood mitigation measures in the Moore Drain, City of Vassar	$1,785,000	$1,125,253	$2,910,253
City of Utica	Macomb	1346.525	Install warning siren	$11,625	$5,175	$16,800
City of Utica	Macomb	1346.85	Elevation of 10 homes	$134,465	$44,822	$179,286
Van Buren Charter Twp.	Wayne	1346.19	Install backup electrical generators at nine sanitary sewer lift stations	$244,670	$81,557	$326,227
Van Buren Charter Twp.	Wayne	1346.21	Flood mitigation on North I-94 Service Drive	$82,979	$27,660	$110,639
Van Buren Charter Twp.	Wayne	1346.22	Install stormwater drains	$226,687	$75,562	$302,249
Van Buren County Drain Commission	Van Buren	1346.55	Construct stormwater detention basin and outlet structure	$4,260	$1,420	$5,680
Van Buren County Drain Commission	Van Buren	1346.69	Construct detention basin in South Haven	$312,375	$162,237	$474,612
Washington Twp.	Macomb	1346.527	Install three warning sirens	$40,875	$25,475	$66,350

Hazard Mitigation Grant Program: Disaster #1346, Urban Flooding, 9/10-11/00 (cont.)

Applicant	County	Application #	Project	Federal Investment	Local Investment	Total Investment
Washtenaw County Community College	Washtenaw	1346.533	Install warning siren	$12,900	$4,300	$17,200
Waterford Twp.	Oakland	1346.508	Engineering and feasibility study for lift station improvements	$17,250	$22,733	$39,983
Waterford Twp.	Oakland	1346.509	Education and public awareness program to reduce storm-related flooding	$5,686	$1,895	$7,582
City of Wayne	Wayne	1346.4	Backup electrical power supply for Stellwagen Sanitary Sewer Pump Station	$40,418	$13,473	$53,891
Wayne County	Wayne	1346.20	Upgrade controls at Pine Street Pumping Station	$85,650	$34,805	$120,455
Wayne County Department of Environment	Wayne	1346.25	Backflow preventers and sump pumps to relieve downriver area basement flooding	$267,414	$107,486	$374,900
City of Williamston	Ingham	1346.73	Bank stabilization / erosion control on Red Cedar River	$28,594	$9,531	$38,126
City of Wyandotte	Wayne	1346.12	Purchase and install 2,300 restricted catch basin covers to reduce sewer backups	$162,070	$54,023	$216,093
			Total for Disaster #1346:	**$24,123,962**	**$10,436,489**	**$34,560,449**

Hazard Mitigation Grant Program: Disaster #1413, Flooding, 4/10-30/02

Applicant	County	Application #	Project	Federal Investment	Local Investment	Total Investment
Charlevoix County Road Commission	Charlevoix	1413.6	Culvert upgrade - Porter Creek Crossing at Anderson and Behling Roads	$21,841	$15,206	$37,047
Emmet County Road Commission	Emmet	1413.1	Replace a culvert with a bridge at Mitchell Road over Minnehaha Creek	$56,436	$86,519	$142,955
Houghton County Road Commission	Houghton	1413.7	Culvert upgrade – Elm River at Old Rink Road	$24,759	$13,151	$37,910
City of Ironwood	Gogebic	1413.4	Insulate a water tower	$72,820	$57,214	$130,034
Lac Vieux Desert Tribal Reservation	(Native American Tribe)	1413.8	Underground conduit extension to mitigate stormwater flooding	$46,735	$17,444	$64,179
Michigan Department of Transportation	Marquette	1413.2	Culvert replacement/upgrade and grade lift on M-35	$149,280	$56,700	$205,980
Michigan Department of Transportation	Houghton	1413.3	Raise Roadway and equalize culvert on M-203	$235,936	$86,662	$322,598
Saginaw County Public Works Commissioner	Saginaw	1413.5	Construct a stormwater relief drain	$89,554	$260,303	$349,857
			Total for Disaster #1413	**$697,361**	**$593,199**	**$1,290,560**

Hazard Mitigation Grant Program: Disaster #1527, Severe Storms and Flooding, 5/20/04–6/8/04

Applicant	County	Application #	Project	Federal Investment	Local Investment	Total Investment
Barry County	Barry	A1527.13	Elevation of 13 homes	$180,583	$61,771	$242,354
Bridgeton Township	Newaygo	A1527.11	Elevation of 1 home	$12,000	$6,638	$18,638
Dearborn Heights, City of	Wayne	A1527.2	Sump pump and backflow valve installation at residential locations	$76,401	$35,264	$111,665
Genesee County Drain Commissioner	Genesee	A1527.8	Site acquisition and demolition	$82,800	$31,597	$114,397
Georgetown Township	Ottawa	A1527.3	Installation of 4 early warning sirens	$58,500	$19,500	$78,000
Kent County	Kent	A1527.10	Acquisition of 3 homes	$430,221	$143,406	$573,627
Ray Township	Macomb	A1527.4	Installation of 1 early warning siren	$17,250	$8,970	$26,220
Robinson Township	Ottawa	A1527.5	Installation of 2 early warning sirens	$27,900	$9,300	$37,200
Rutland Township	Barry	A1527.17	Acquisition of 1 home	$67,830	$22,610	$90,441
Salem Township	Allegan	A1527.6	Installation of 2 early warning sirens	$26,250	$8,750	$35,000
St. Clair County Road Commission	St. Clair	A1527.15	Removal of twin arch pipes and installation of large box culvert to increase flow capacity	$87,876	$29,292	$117,168
Wayne Township	Cass	A1527.7	Installation of 1 early warning siren	$19,665	$6,555	$26,220
			Total for Disaster #1527	**$1,087,275**	**$383,654**	**$1,470,929**

Hazard Mitigation Grant Program: Disaster #1777, Severe Storms and Flooding, 6/6/08–6/13/08

Applicant	County	Application #	Project	Federal Investment	Local Investment	Total Investment
Ann Arbor, City of	Washtenaw	A1777.12	Demolition of city building from floodway	$25,632	$8,544	$34,176
Blendon Township	Ottawa	A1777.1	Installation of 2 early warning sirens	$31,111	$10,370	$41,481
Bloomfield Township	Oakland	A1777.7	Local mitigation plan development	$10,822	$3,607	$14,430
Caledonia Township	Kent	A1777.2	Installation of 2 early warning sirens	$29,850	$15,721	$45,571
Caledonia, Village of	Kent	A1777.3	Installation of 1 early warning siren	$14,925	$7,337	$22,262
Commerce Township	Oakland	A1777.4	Installation of 4 early warning sirens	$59,376	$19,792	$79,168
Eastern Michigan University	Washtenaw	A1777.10	Local mitigation plan development	$12,010	$23,259	$35,269
Grand Haven, City of	Ottawa	A1777.5	Installation of 1 early warning siren	$14,025	$4,675	$18,700
Lansing, City of	Ingham	A1777.11	Acquisition-Demo (20 properties)	$752,897	250,965	$1,003,862
Plainfield Charter Twp.	Kent	A1777.9	Acquisition-Demo (13 properties)	$1,124,325	374,775	$1,499,100
Pokagon Band of Potawatomi Indians	Cass	A1777.8	Tribal mitigation plan development	$15,000	$5,000	$20,000
Springfield Township	Oakland	A1777.6	Installation of 3 early warning sirens	$44,532	$14,844	$59,376
			Total for Disaster #1777	**$2,134,505**	**$738,889**	**$2,889,804**
			Totals for Disasters #1028, 1128, 1181, 1226, 1237, 1346, 1413, 1527, and 1777:	**$36,876,437**	**$16,215,432**	**$53,108,277**

Summary of Flood Mitigation Assistance Program (FMAP) Projects Funded in Michigan: 1996-2013

Applicant	County	Fiscal Year	Project	Federal Investment	Local Investment	Total Investment
Vassar, City of	Tuscola	1996/97	Development of flood hazard mitigation plan.	$9,678	$3,226	$12,904
Midland, City of	Midland	1996/97	Development of flood hazard mitigation plan.	$4,098	$1,366	$5,464
Vassar, City of	Tuscola	1996/97	Technical assistance in the development of flood hazard mitigation plan.	$15,890	$5,297	$21,187
New Baltimore, City of	Macomb	1996/97	Flood mitigation project in support of flood hazard mitigation plan.	$15,000	$5,613	$20,613
Clinton Township	Macomb	1996/97	Flood mitigation project in support of flood hazard mitigation plan.	$36,375	$21,687	$58,062
Macomb County	Macomb	1998	Development of flood hazard mitigation plan.	$7,850	$4,150	$12,000
Michigan Dept. of Environmental Quality	(State Agency)	1998	Identify high-risk flood zones in unmapped areas of Macomb County and update hydrology.	$16,030	$5,343	$21,373
Vassar, City of	Tuscola	1998	Flood acquisition/relocation project in support of flood hazard mitigation plan.	$126,118	$42,039	$168,157
Dearborn Heights, City of	Wayne	1999	Development of flood hazard mitigation plan.	$6,740	$2,247	$8,986
Dearborn Heights, City of	Wayne	1999	Technical assistance in the development of flood hazard mitigation plan.	$15,310	$5,103	$20,413
Allegan County	Allegan	2000	Development of flood hazard mitigation plan.	$14,200	$4,733	$18,933
Allegan County	Allegan	2000	Technical assistance in the development of flood hazard mitigation plan.	$15,050	$5,017	$20,067
Vassar, City of	Tuscola	2000	Flood mitigation project in support of flood hazard mitigation plan.	$80,787	$26,929	$107,716
Marquette County	Marquette	2001	Development of flood hazard mitigation plan.	$13,900	$4,633	$18,533
Marquette County	Marquette	2001	Technical assistance in the development of flood hazard mitigation plan.	$14,750	$4,917	$19,667
Frenchtown Township	Monroe	2002	Development of flood hazard mitigation plan.	$10,275	$7,318	$17,593
Frenchtown Township	Monroe	2002	Technical assistance in the development of flood hazard mitigation plan.	$9,413	$6,704	$16,117
Ann Arbor, City of	Washtenaw	2003	Development of flood hazard mitigation plan.	$12,600	$4,207	$16,807
Ann Arbor, City of	Washtenaw	2003	Technical assistance in the development of flood hazard mitigation plan.	$11,450	$3,817	$15,267
Bridgeton Township	Newaygo	2004	Development of flood hazard mitigation plan.	$12,500	$4,167	$16,667
Bridgeton Township	Newaygo	2004	Technical assistance in the development of flood hazard mitigation plan.	$13,120	$4,373	$17,493
Wakefield, City of	Gogebic	2005	Development of flood hazard mitigation plan.	$13,700	$4,567	$18,267
Wakefield, City of	Gogebic	2005	Technical assistance in the development of flood hazard mitigation plan.	$14,439	$4,814	$19,253

Summary of Flood Mitigation Assistance Program (FMAP) Projects Funded in Michigan: 1996-2013 (cont.)

Applicant	County	Fiscal Year	Project	Federal Investment	Local Investment	Total Investment
Kalamazoo, City of	Kalamazoo	2005	Development of flood hazard mitigation plan.	$13,900	$6,980	$20,880
Plainfield Township	Kent	2005	Development of flood hazard mitigation plan.	$13,700	$18,312	$32,012
Bloomfield Township	Oakland	2006	Development of flood hazard mitigation plan.	$15,899	$5,653	$21,552
Ottawa County	Ottawa	2008	Update of flood hazard mitigation plan.	$1,058	$367	$1,424
Plainfield Township	Kent	2008	Elevation of flood prone homes	$8,158	$3,332	$11,490
Plainfield Township	Kent	2009	Acquisition/demolition of 12 flood prone homes	$1,155,853	$385,284	$1,541,137
Midland, City of	Midland	*2013	Acquisition of commercial facility from floodplain	$1,029,693	$0	$1,029,693
			TOTALS TO DATE: FY 1996/97-2013	**$2,727,532**	**$602,195**	**$3,329,727**

Three types of grants have been available under the FMAP: **Planning; Technical Assistance; Project**. **Planning Grants** provide assistance to states and local communities in developing flood mitigation plans. **Technical Assistance Grants** (no longer available) enabled states to provide technical assistance to applicants in applying for FMAP funds or in implementing approved projects. **Project Grants** help fund eligible flood mitigation projects that reduce the risk of flood damage to NFIP-insurable structures. The table above will not necessarily identify one of each type of grant for each fiscal year. In some fiscal years, allocations were returned to FEMA if viable grant applications were not submitted by local entities. In Fiscal Year 2009, the FMAP became a nationally competitive grant program (with no state specific allocations) that could fund mitigation projects or flood mitigation plans.

*At the time of this writing, funds have not yet been obligated for this grant.

Summary of Pre-Disaster Mitigation Program (PDMP) Projects Funded in Michigan: 2002-2013

Applicant	County	Fiscal Year	Project	Federal Investment	Local Investment	Total Investment
Canton Township	Wayne	2002	Development of an all-hazard mitigation plan.	$14,627	$30,239	$44,867
Detroit, City of	Wayne	2002	Development of an all-hazard mitigation plan.	$23,357	$55,843	$79,200
Lincoln Park, City of	Wayne	2002	Development of an all-hazard mitigation plan.	$12,630	$30,195	$42,825
Livonia, City of	Wayne	2002	Development of an all-hazard mitigation plan.	$9,280	$22,186	$31,465
Romulus, City of	Wayne	2002	Development of an all-hazard mitigation plan.	$4,905	$11,728	$16,633
Wayne County	Wayne	2002	Development of an all-hazard mitigation plan.	$156,948	$140,935	$297,883
Barry County	Barry	2003	Development of an all-hazard mitigation plan.	$2,571	$7,711	$10,282
Berrien County	Berrien	2003	Development of an all-hazard mitigation plan.	$7,437	$21,195	$28,632
Saginaw County	Saginaw	2003	Development of an all-hazard mitigation plan.	$15,063	$30,021	$45,084
St. Clair County	St. Clair	2003	Development of an all-hazard mitigation plan.	$16,699	$47,591	$64,290
Van Buren County	Van Buren	2003	Development of an all-hazard mitigation plan.	$13,102	$21,000	$34,102
Robinson Township	Ottawa	2005	Acquisition of 4 structures and 8 vacant parcels out of the Grand River floodplain	$703,552	$234,518	$938,070
Robinson Township	Ottawa	2005	Acquisition of 5 structures and 1 vacant parcels out of the Grand River floodplain	$221,502	$664,505	$886,007
Michigan Technological University	Houghton	2005	Development of an all hazard mitigation plan	$56,250	$18,750	$75,000
Ada Township	Kent	2006	Acquisition and demolition of 1 structure	$63,824	$21,275	$85,099
Lansing, City of	Ingham	2008	Acquisition of 22 residential properties from the floodplain	$534,052	$209,291	$743,343
Detroit, City of	Wayne	*2008	Burial of overhead power lines	$1,580,074	$526,692	$2,106,766
Marquette County	Marquette	2009	Dune stabilization along state highway	$99,596	$33,267	$132,863
Marquette County	Marquette	2009	Culvert upgrade	$76,470	$25,490	$101,960
University of Michigan – Flint	Genesee	2009	Development of an all-hazard mitigation plan.	$45,048	$15,333	$60,381
Ann Arbor, City of	Washtenaw	2009	Acquisition of 1 home and 1 vacant parcel	$169,966	$56,655	$226,622
Wayne County	Wayne	2009	Install 18 outdoor warning sirens	$270,825	$90,275	$361,100
Gogebic County	Gogebic	2010	Update of a county hazard mitigation plan	$29,959	$10,012	$39,971
Houghton County	Houghton	2010	Update of 5 county hazard mitigation plans	$30,070	$10,030	$40,100

Summary of Pre-Disaster Mitigation Program (PDMP) Projects Funded in Michigan: 2002-2013 (cont.)

Applicant	County	Fiscal Year	Project	Federal Investment	Local Investment	Total Investment
Oakland County	Oakland	2010	Update of a county hazard mitigation plan	$132,225	$45,164	$177,389
Chippewa County	Chippewa	2011	Update of 3 county hazard mitigation plans	$26,670	$9,381	$36,051
Delta County	Delta	2011	Update of 4 county hazard mitigation plans	$50,248	$16,752	$67,000
Detroit, City of	Wayne	2011	Update of the Detroit Hazard Mitigation Plan	$47,775	$15,925	$63,700
Ingham County	Ingham	2011	Update of 3 county hazard mitigation plans	$81,663	$30,832	$112,495
Kalamazoo, City of	Kalamazoo	2011	Acquisition of 9 homes in the floodplain.	$309,538	$103,799	$413,337
Kent County	Kent	2011	Acquisition of 8 homes in the floodplain.	$856,715	$285,572	$1,142,286
Marquette County	Marquette	2011	Planning update for Marquette County HMP.	$29,115	$9,705	$38,820
Oceana County	Oceana	2011	Update of 5 county hazard mitigation plans	$250,000	$83,335	$333,335
Otsego County	Otsego	2011	Update of 7 county hazard mitigation plans	$85,575	$28,675	$114,250
Plainfield Township	Kent	2011	Acquisition of 6 homes in the floodplain.	$480,300	$160,100	$640,400
Allegan County	Allegan	2012	Planning update for Allegan County	$18,150	$6,050	$24,200
Emmet County	Emmet	2012	Update of 3 county hazard mitigation plans	$34,634	$11,545	$46,178
Mount Clemens, City of		2012	Stormwater Improvement Project	$62,500	$27,500	$90,000
GLS Region V	GLS Region V	2012	Update of 2 county hazard mitigation plans	$99,920	$24,980	$99,920
St. Clair County	St. Clair	2012	Hazard mitigation plan update for St. Clair County	$21,375	$7,125	$28,500
Roscommon County	Roscommon	2012	Update of 5 county hazard mitigation plans	$112,500	$37,500	$150,000
Shiawassee County	Shiawassee	2012	Hazard mitigation plan update for Shiawassee County	$102,870	$34,290	$137,160
Leelanau County	Leelanau	2012	Update of 8 county hazard mitigation plans	$124,050	$41,900	$165,950
Estral Beach, Village of	Monroe	*2013	Develop a village hazard mitigation plan	$9,806	$3,269	$13,075
Lansing, City of	Ingham	*2013	Acquisition of 19 residential properties from the floodplain	$249,975	$83,325	$333,300
Tuscola County	Tuscola	*2013	Hazard mitigation plan update for Tuscola County	$16,923	$5,642	$22,565
			TOTALS TO DATE: FY 2002-2013	**$7,360,334**	**$3,407,103**	**$10,742,456**

Two types of grants available under the PDMP: **Planning and Project**. **Planning Grants** provide assistance to states and local communities in developing all-hazard mitigation plans. **Project Grants** help fund eligible mitigation projects that eliminate or reduce damages to public or private property from natural hazards.

*At the time of this writing funds have not yet been obligated for this grant.

Summary of Repetitive Flood Claims Program (RFCP) Projects Funded in Michigan: 2006 and 2012

Applicant	County	Fiscal Year	Project	Federal Investment	Local Investment	Total Investment
Mecosta Township	Mecosta	2006	Acquisition and demolition of one structure	$109,965	$0	$109,965
Estral Beach, Village of	Monroe	2012	Elevation of three homes in the floodplain	$152,000	$0	$152,000
			TOTALS TO DATE: FY 2006 and 2012	**$261,965**	**$0**	**$261,965**

Only one type of grant is available under the RFCP – **project grants**: There is no local share under the RFCP as the program is 100% federally funded.

MITIGATION PROJECT FUNDING MADE AVAILABLE IN MICHIGAN SINCE 1994, BY COUNTY (AS OF MAY 2013)

COUNTY	PROJECT TOTAL	FEDERAL SHARE
Alcona	$ 297,992	$ 180,000
Allegan	$ 413,235	$ 308,607
Alpena	$ 566,540	$ 367,088
Antrim	$ 447,511	$ 286,258
Arenac	$ 215,840	$ 127,875
Baraga	$ 78,702	$ 56,255
Barry	$ 332,795	$ 248,413
Bay	$ 3,083,644	$ 2,467,959
Cass	$ 87,520	$ 60,540
Charlevoix	$ 432,579	$ 301,456
Cheboygan	$ 17,876	$ 13,407
Chippewa	$ 566,652	$ 424,989
Crawford	$ 1,967	$ 1,475
Delta	$ 12,575	$ 9,432
Dickinson	$ 84,701	$ 63,297
Eaton	$ 320,086	$ 225,000
Emmet	$ 142,955	$ 56,436
Genesee	$ 4,956,999	$ 3,719,810
Gogebic	$ 609,918	$ 330,089
Grand Traverse	$ 76,989	$ 57,742
Gratiot	$ 405,181	$ 277,352
Houghton	$ 651,742	$ 478,846
Huron	$ 587,630	$ 376,500
Ingham	$ 1,950,331	$ 1,439,293
Ionia	$ 399,372	$ 298,243
Iosco	$ 154,696	$ 67,511
Iron	$ 209,825	$ 148,742
Isabella	$ 58,744	$ 44,059
Jackson	$ 107,637	$ 76,797
Kalamazoo	$ 84,318	$ 63,239
Kent	$ 8,877,038	$ 6,455,211
Keweenaw	$ 150,652	$ 112,500
Lake	$ 27,940	$ 20,000
Lapeer	$ 5,421	$ 4,066
Leelanau	$ 21,975	$ 13,875
Lenawee	$ 147,448	$ 110,586
Livingston	$ 590,470	$ 442,852
Mackinac	$ 273,754	$ 183,750
Macomb	$ 2,374,738	$ 1,376,530
Marquette	$ 2,130,426	$ 1,313,288
Mason	$ 27,940	$ 20,000
Mecosta	$ 109,965	$ 109,965
Midland	$ 84,056	$ 58,637
Monroe	$ 1,642,496	$ 1,318,570
Muskegon	$ 343,898	$ 257,923
Newaygo	$ 18,638	$ 12,000
Oakland	$ 3,826,141	$ 2,544,356

Ogemaw	$	202,325	$	150,000
Ontonagon	$	64,811	$	48,379
Osceola	$	27,940	$	20,000
Otsego	$	2,106	$	1,575
Ottawa	$	4,303,289	$	3,083,578
Saginaw	$	4,060,032	$	2,664,727
Sanilac	$	615,471	$	375,316
St. Clair	$	356,259	$	267,195
St. Joseph	$	327,175	$	245,381
Tuscola	$	4,010,683	$	2,592,157
Van Buren	$	480,292	$	316,635
Washtenaw	$	536,155	$	402,116
Wayne	$	4,931,743	$	3,633,023
Wexford	$	846,431	$	634,823
Statewide (other)	$	1,246,019	$	827,041
TOTAL in Michigan	$	60,020,279	$	42,192,768

- The totals in this table represent 269 separate project grants. Two-hundred-fifty-six (256) of the projects are complete and the totals included in the table are based actual project costs. For the thirteen (13) grants that were awarded but not yet complete as of May 2013, projected totals were used based on grant application budgets.
- This table includes totals from two multi-county projects that benefitted a total of seven counties. The completed project totals for those two projects were evenly distributed to the counties they benefitted.
- There were a total of twelve projects that yielded benefits that were statewide or regional in nature. Those twelve projects are totaled under the category of "Statewide (other)".
- The project grant totals represented in this table are from grants awarded to the State of Michigan from the Federal Emergency Management Agency (FEMA). The grants were awarded four of FEMA's five separate grant programs that are collectively known as Hazard Mitigation Assistance (HMA). The four grant programs represented in this table are the Hazard Mitigation Grant Program (HMGP), the Flood Mitigation Assistance (FMA) program, the Pre-Disaster Mitigation (PDM) program, and the Repetitive Flood Claims (RFC) program. All grants, other than totaled in the "Statewide (other)" category, were passed through from the State of Michigan to local units of government.

MCCERCC Information

Executive Order 2007-18:
Michigan Citizen-Community Emergency Response Coordinating Council

Michigan Citizen-Community Emergency Response Coordinating Council Members

EXECUTIVE ORDER No. 2007-18
(REFORMATTED ELECTRONIC COPY)

MICHIGAN CITIZEN-COMMUNITY EMERGENCY RESPONSE COORDINATING COUNCIL

WHEREAS, Section 1 of Article V of the Michigan Constitution of 1963 vests the executive power of the State of Michigan in the Governor;

WHEREAS, under Section 8 of Article V of the Michigan Constitution of 1963 the Governor is responsible for taking care that the laws be faithfully executed;

WHEREAS, under Section 8 of Article V of the Michigan Constitution of 1963 each principal department of state government is under the supervision of the Governor unless otherwise provided by the Constitution;

WHEREAS, this administration continues to be committed to encouraging all residents, organizations, and institutions in Michigan to help in solving our most critical problems by volunteering their time, effort, energy and service in times of prosperity as well as crisis;

WHEREAS, the need for homeland security, community health, public safety, and all-hazard preparedness have increased and have led to the need to call upon the compassion, inventiveness, and volunteer spirit of all Michigan residents to help solve many of the problems facing our communities;

WHEREAS, state government has a unique role to play in coordinating hazard mitigation and emergency response activities of state and local governments;

WHEREAS, it is appropriate that state government rely upon appropriate technical expertise and input from the general public in coordinating hazard mitigation and emergency response activities;

WHEREAS, the Michigan Citizen Corps Council was created within the Michigan Community Service Commission under Executive Order 2002-9 to oversee the development and operation of the Michigan Citizen Corps Council and to act as a state-wide advisory council on the Michigan Citizen Corps;

WHEREAS, while under Executive Order 2002-9, the Michigan Citizen Corps Council was charged with the development of initiatives to promote, among other things, the federal Terrorist Information and Prevention System (TIPS), federal law now prohibits activities to implement the TIPS component of the Citizen Corps initiative;

WHEREAS, the Michigan Citizen Corps Council failed to report to the Governor and the Legislature as required under Executive Order 2002-9;

WHEREAS, the Michigan Emergency Planning and Community Right-to-Know Commission was established by Executive Order 1994-17, as amended by Executive Orders 1994-25 and 1995-23, and designated as the emergency response commission for this state as required by the federal Emergency Planning and Community Right-to-Know Act of 1986;

WHEREAS, the Michigan Hazard Mitigation Coordinating Council was established by Executive Order 1998-5 to assist in preventing or lessening the damage and impact of disasters and emergencies through hazard mitigation;

WHEREAS, the work of the Michigan Citizen Corps Council, the Michigan Emergency Planning and Community Right-to-Know Commission, and the Michigan Hazard Mitigation Coordinating Council can be coordinated more effectively by a single new entity within the Department of State Police;

NOW, THEREFORE, I, Jennifer M. Granholm, Governor of the State of Michigan, by virtue of the power and authority vested in me by the Michigan Constitution of 1963 and Michigan law, order the following:

I. DEFINITIONS

A. "Civil Service Commission" means the commission authorized under Section 5 of Article XI of the Michigan Constitution of 1963.

B. "Council" means the Michigan Citizen-Community Emergency Response Coordinating Council created as an advisory body within the Department of State Police under this Order.

C. "Community Service Commission" means the Michigan Community Service Commission established under 1994 PA 219, MCL 408.221 to 408.232, that was subsequently transferred to the Department of Career Development by Executive Order 1999-1, as amended, MCL 408.40, to the Department of Labor and Economic Growth by Executive Order 2003-18, MCL 445.2011, and to the Department of Human Services by Executive Order 2006-18, MCL 400.561.

D. "Department of Management and Budget" means the principal department of state government created under Section 121 of The Management and Budget Act, 1984 PA 431, MCL 18.1121.

E. "Department of State Police" or "Department" means the Department of State Police created under Section 150 of the Executive Organization Act of 1965, 1965 PA 380, MCL 16.250.

F. "Michigan Citizen Corps" means the Michigan initiative created under the federal USA Freedom Corps program pursuant to Executive Order 2002-9 and other applicable state and federal law.

G. "Michigan Citizen Corps Council" means the advisory body created within the Michigan Community Service Commission under Executive Order 2002-9.

H. "Michigan Emergency Planning and Community Right-to-Know Commission" means the advisory body created within the Department of State Police under Executive Order 1994-17, as amended by Executive Orders 1994-25 and 1995-23.

I. "Michigan Hazard Mitigation Coordinating Council" means the advisory body established within the Department of State Police by Executive Order 1998-5.

J. "USA Freedom Corps" means the federal interagency initiative created under Executive Order No. 13254, 67 CFR 4869, and any successor program.

II. CREATION OF THE COUNCIL

A. The Michigan Citizen-Community Emergency Response Coordinating Council is created as an advisory body within the Department of State Police.

B. The Council shall consist of the following members:

1. The Director of the Department of Agriculture or his or her designated representative from within the Department of Agriculture.

2. The Director of the Department of Community Health or his or her designated representative from within the Department of Community Health.

3. The Director of the Department of Environmental Quality or his or her designated representative from within the Department of Environmental Quality.

4. The Adjutant General or his or her designated representative from within the Department of Military and Veterans Affairs.

5. The Director of the Department of State Police or his or her designated representative from within the Department.

6. The Director of the Department of Transportation or his or her designated representative from within the Department of Transportation.

7. The State Fire Marshal.

8. The Executive Director of the Community Service Commission or his or her designee from within the Community Service Commission.

9. Eleven individuals appointed by the Governor, including at least two individuals with technical expertise related to emergency response.

10. Of the 11 members initially appointed by the Governor under Section II.B.9, 3 members shall be appointed for terms expiring on December 31, 2007, 3 members shall be appointed for terms expiring on December 31, 2008, 3 members shall be appointed for terms expiring on December 31, 2009, and 2 members shall be appointed for terms expiring on December 31, 2010. After the initial terms, members of the Council shall be appointed to 4-year terms.

C. A vacancy on the Council occurring other than by expiration of a term shall be filled in the same manner as the original appointment for the balance of the unexpired term.

D. The Governor shall designate a member of the Council to serve as its Chairperson at the pleasure of the Governor. The Governor may designate a member of the Council to serve as its Vice-Chairperson at the pleasure of the Governor.

III. CHARGE TO THE COUNCIL

A. The Council shall act in an advisory capacity to the Department of State Police and shall do all of the following:

1. Monitor and advise the Department regarding the development and operation of the Michigan Citizen Corps.

2. Act as the statewide advisory council for the Michigan Citizen Corps.

3. Develop for presentation to the Department a comprehensive Michigan Community Emergency Response and Citizen Corps Coordination Plan ("Plan") in consultation with the Department of State Police, the Department of Community Health, the Department of Environmental Quality, the Department of Military and Veterans Affairs, the Office of the State Fire Marshal, and other emergency management entities, including local and tribal entities. The Plan shall provide for all of the following:

a. Coordination of the use of volunteer resources in Michigan in furtherance of homeland security and emergency response.

b. Description of volunteer recruitment and plans for volunteer-management related to emergencies in times of declared states of emergency or disaster.

c. Analysis of state agency coordination plans related to volunteer recruitment and emergency management.

d. Detail of state, local, and tribal activities that may help in the further development of the Michigan Citizen Corps and coordination of citizen-based community emergency response efforts.

e. Reporting on best practices in local and tribal citizen-based emergency response activities and recognizing accomplishments.

4. Beginning September 30, 2009, annually update and submit the Plan required under Section III.C.3 to the Director of the Department of State Police and the Executive Director of the Michigan Community Service Commission no later than 60 days after the close of each fiscal year.

5. Identify opportunities for local, state, tribal, and federal organizations to collaborate to accomplish the shared goals of Citizen Corps and other citizen-based community emergency response efforts.

6. Assist and advise the Department of State Police, the Community Service Commission and local and tribal entities with the preparation of grant and other funding applications submitted to the USA Freedom Corps and other public and private funding sources for implementing the Michigan Citizen Corps and other citizen-based community emergency response efforts.

7. Assist and advise the Department of State Police and the Community Service Commission with the establishment of policies and procedures regarding the use of grants and other funds related to the USA Freedom Corps, the Michigan Citizen Corps, and other citizen-based community emergency response efforts, subject to appropriations and applicable law.

8. Assist and advise the Department of State Police and the Community Service Commission with the development, establishment, and promotion of local Citizen Corps councils, local Citizen Corps programs, and other citizen-based community emergency response and homeland security initiatives.

9. Assist and advise the Department of State Police and the Community Service Commission in the development of programs and activities to promote community service related to homeland security and citizen-based community emergency response, including, but not limited to: Volunteers in Police Service, Neighborhood Watch, Medical Reserve Corps, and Community Emergency Response Teams.

10. Assist and advise the Department of State Police and the Community Service Commission regarding public education, training, and volunteer opportunities related to homeland security and citizen-based community emergency response.

11. Recommend policies and procedures to ensure that emergency response volunteers are connected to emergency alert systems.

12. Recommend policies and procedures to be used by the Michigan Citizen Corps and local Citizen Corps programs in responding to requests for volunteer assistance from other states.

13. Coordinate on behalf of the Department of State Police or the Community Service Commission activities relating to reports to the federal government regarding Citizen Corps and other related activity in Michigan.

B. The Council is designated as the state emergency response commission required under Section 301 of the federal Emergency Planning and Community Right-to-Know Act, Title III of the Superfund Amendments and Reauthorization Act of 1986, 42 USC 11001 to 11050 ("Act") and shall perform all of the duties of a state emergency response commission under the Act, including, but not limited to, all of the following:

1. Appointing local emergency planning committees for each county of this state. Each local emergency planning committee shall include, at a minimum, representatives from each of the following groups or organizations: elected state and local officials; law enforcement, civil defense, firefighting, first aid, health, local environmental, hospital, and transportation personnel; broadcast and print media; community groups; and owners and operators of facilities subject to the requirements of Subchapter I of the Act, 42 USC 11001 to 11005. Each local emergency planning committee shall appoint a chairperson and establish rules for the functioning of the committee, with the rules including provisions for public notification of committee activities, public meetings to discuss emergency plans, public comments, response to such comments by the committee, and distribution of emergency plans. Local emergency planning committees shall comply with the Freedom of Information Act, 1976 PA 442, MCL 15.231 to 15.246, and the Open Meetings Act, 1976 PA 267, MCL 15.261 to 15.275. Each local emergency planning committee shall establish procedures for receiving and processing requests from the public for information under Section 324 of the Act, 42 USC 11044, including tier II information under Section 312 of the Act, 42 USC 11022, and procedures for the designation of an official to

serve as coordinator for the information. Each local emergency planning committee shall perform the functions required of local emergency planning committees under the Act.

2. Notifying the Administrator of the federal Environmental Protection Agency of facilities subject to the requirements of the Act and of each notification received from a facility under Section 302(c) of the Act, 42 USC 11002(c).

3. Reviewing plans submitted by local emergency planning committees and make recommendations to the committees on revisions that may be necessary to ensure coordination with other emergency planning districts.

4. Protecting the public health, safety, welfare, and the environment by facilitating the implementation of the emergency planning and community right-to-know provisions of the Act.

5. Evaluating state agency responsibilities regarding hazardous materials planning, enforcement, and response, and develop recommendations to ensure efficient and effective coordination of hazardous materials planning, enforcement, and response.

C. The Council shall perform the following functions relating to hazard mitigation planning and coordination:

1. Assisting in the development, maintenance, and implementation of a state hazard mitigation plan.

2. Assisting in the development, maintenance, and implementation of guidance and informational materials to support hazard mitigation efforts of local and state government, and private entities.

3. Soliciting, reviewing, and identifying hazard mitigation projects for funding, including, but not limited to, federal funding under Section 404 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act, 42 USC 5170c, and Sections 553 and 554 of the National Flood Insurance Reform Act of 1994, 42 USC 4104c and 42 USC 4014d.

4. Fostering and promoting, where appropriate, hazard mitigation principles and practices within local and state government, and with the general public.

IV. OPERATIONS OF THE COUNCIL

A. The Council shall be staffed by personnel from and assisted by the Department of State Police. Any budgeting, procurement, and related management functions of the Council shall be performed under the direction and supervision of the Director of the Department of State Police.

B. The Council shall select from among its members a Secretary. Council staff shall assist the Secretary with recordkeeping responsibilities.

C. Members of the Council appointed by the Governor under Section II.B.9 shall not delegate their responsibilities as members to other persons. A majority of the members of the Council serving constitutes a quorum for the transaction of the Council's business. The Council shall act by a majority vote of its serving members.

D. The Council shall adopt procedures consistent with Michigan law and this Order governing its organization and operations and may establish committees and request public participation on advisory panels as the Council deems necessary. The Council may also adopt, reject, or modify any recommendations proposed by committees or advisory panels.

E. The Council shall meet at the call of the Chairperson and as may be provided in procedures adopted by the Council.

F. In developing recommendations, the Council may, as appropriate, make inquiries, studies, investigations, hold hearings, and receive comments from the public. The Council may also consult with outside experts in order to perform its duties, including, but not limited to, experts in the private sector, organized labor, government agencies, and at institutions of higher education.

G. Members of the Council shall serve without compensation but may receive reimbursement for necessary travel and expenses according to relevant statutes and the rules of procedures of the Civil Service Commission and the Department of Management and Budget, subject to available appropriations.

H. The Council may hire or retain contractors, sub-contractors, advisors, consultants, and agents, and may make and enter into contracts necessary or incidental to the exercise of the powers of the Council and the performance of its duties as the Chairperson deems advisable and necessary, in accordance with this Order, and the relevant statutes, rules, and procedures of the Civil Service Commission and the Department of Management and Budget.

I. The Council may accept donations of labor, services, or other things of value from any public or private agency or person. Any donations shall be expended in accordance with applicable laws, rules, and procedures.

J. Members of the Council shall refer all legal, legislative, and media contacts to the Department of State Police.

V. RESCISSIONS

A. The Michigan Citizen Corps Council created under Executive Order 2002-9 is abolished.

B. Executive Order 2002-9 is rescinded in its entirety.

C. The Michigan Hazard Mitigation Coordinating Council created under Executive Order 1998-5 is abolished.

D. Executive Order 1998-5 is rescinded in its entirety.

E. The State Emergency Planning and Community Right-to-Know Commission established under Executive Order 1994-17, as amended by Executive Orders 1994-25 and 1995-23, is abolished.

F. Executive Orders 1987-5, 1988-1, 1994-17, 1994-25, and 1995-23 are rescinded in their entirety.

VI. MISCELLANEOUS

A. All departments, committees, commissioners, or officers of this state or of any political subdivision of this state shall give to the Council, or to any member or representative of the Council, any necessary assistance required by the Council, or any member or representative of the Council, in the performance of the duties of the Council so far as is compatible with its, his, or her duties. Free access also shall be given to any books, records, or documents in its, his, or her custody, relating to matters within the scope of inquiry, study, or investigation of the Council.

B. Any suit, action, or other proceeding lawfully commenced by, against, or before any entity affected by this Order shall not abate by reason of the taking effect of this Order.

C. The invalidity of any portion of this Order shall not affect the validity of the remainder of the Order.

This Order is effective upon filing.

Given under my hand and the Great Seal of the State of Michigan this 2nd day of May in the year of our Lord, two thousand seven.

_____

JENNIFER M. GRANHOLM
GOVERNOR

BY THE GOVERNOR:

_____

Secretary of State

Michigan Citizen-Community Emergency Response Coordinating Council: Current Members (as of February 2014)

Mr. Brad Deacon
Designated representative from the Michigan Department of Agriculture and Rural Development.

Mr. Marc C. Breckenridge
Technical expert related to emergency response. Washtenaw County Emergency Management Coordinator.

Mr. John H. Cauley
General public representative. Mid-Michigan Chapter of the American Red Cross.

Mr. Richard Miller
State Fire Marshal, Michigan Department of Licensing and Regulatory Affairs.
Designated representative from the Michigan State Fire Marshal.

Mr. Kenneth J. Gembel
Technical expert related to emergency response. General Motors Corporation.

Chief Gary Hagler
Designated representative from the Michigan Department of Environmental Quality.

Dr. William D. Fales
Technical expert related to emergency response. Western Michigan University.

Ms. Virginia Holmes
Designated representative from the Michigan Community Service Commission.

Dr. Phillip D. Schertzing
General public representative. Michigan State University.

Ms. Gail A. Novak-Phelps
Technical expert related to emergency response. White Lake Township Planning Commission; former Oakland County Emergency Manager.

Ms. Eileen Phifer
Designated representative from the Michigan Department of Transportation.

Capt. Chris A. Kelenske
Deputy State Director of Emergency Management & Homeland Security
Designated representative from the Michigan Department of State Police.

Dr. Jackie S. Scott
Designated representative from the Michigan Department of Community Health.

LTC Gregory A. Durkac
Designated representative from the Michigan Department of Military and Veterans Affairs.

Vacant
Technical expert related to emergency response.

Vacant
Technical expert related to emergency response.

Vacant
Technical expert related to emergency response.

Vacant
Technical expert related to emergency response.

Vacant
General public representative.

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EXECUTIVE DIRECTIVE No. 2001 - 5 (ELECTRONIC COPY)

STATE FLOOD HAZARD MITIGATION

DATE: September 11, 2001

TO: All Directors and Agency Heads

FROM: Governor John Engler (signed)

SUBJECT: State Flood Hazard Mitigation

Recent flood events in Michigan are serious reminders that economic losses from flood damage can occur regardless of season and in spite of the current low Great Lakes water levels. Last September's flooding in southeast Michigan resulted in the most expensive Presidential Disaster Declaration in the history of the state of Michigan. The federal and state governments have expended more than $200 million responding to this flood event.

The state of Michigan has extensive and continuous programs for the construction of buildings, roads and other facilities, which influence patterns of commercial, residential and industrial development in flood-prone areas. State agencies play an important role in avoiding the uneconomic, hazardous or unnecessary use of floodplains for activities that impair the beneficial functions of such areas. Furthermore, state agencies, leading by example, can provide local government and the public with a model that allows for optimum floodplain management and the mitigation of existing flood hazards.

Therefore, I direct the Department of Environmental Quality ("DEQ"), as the lead agency, to develop a statewide, inter-agency, flood mitigation strategy to assure compliance with the State Flood Hazard Mitigation Plan. In many respects, this strategy will involve the implementation of aspects of the State Flood Hazard Mitigation Plan, which was originally developed pursuant to the provisions of Executive Order 1977-4 issued by Governor William G. Milliken. The Michigan Hazard Mitigation Coordinating Council, an entity created by Executive Order 1998-5, currently assists in the development, maintenance and implementation of the State Flood Hazard Mitigation Plan.

The DEQ shall develop this strategy in cooperation with the Department of State Police, the Department of Consumer and Industry Services ("CIS"), the Department of Management and Budget ("DMB"), the Department of Transportation, and the Michigan Hazard Mitigation Coordinating Council. Other state departments and agencies shall cooperate in the development of the strategy as requested by DEQ.

In addition to general provisions implementing the State Flood Hazard Mitigation Plan, the mitigation strategy shall specifically include the following:

1. A review of administrative rules promulgated by DEQ found in Part 13 – Floodplains and Floodways, of the DEQ's Water Resources Protection rules, located at R. 323.1311 et seq. of the Michigan Administrative Code. This review shall determine if current regulations adequately prevent state activities that cause the loss of water storage capacity in the state's floodplains. Additionally, the review shall determine if current regulations provide adequate flood resistant construction standards for state riverine and inland lake floodplain construction activities. The strategy shall recommend changes in the applicable regulations when necessary and appropriate to assure compliance with the State Flood Hazard Mitigation Plan.

2. A review of administrative rules promulgated by DEQ entitled Great Lakes Shorelands located at R. 281.21 et seq. of the Michigan Administrative Code. This review shall determine if current regulations include adequate measures to assure flood resistant construction standards apply to state construction activities in Great Lakes floodplains. The strategy shall recommend changes in the applicable regulations when necessary and appropriate to assure compliance with the State Flood Hazard Mitigation Plan.

3. A review of administrative rules promulgated by the Department of Consumer and Industry Services ("CIS") addressing Land Divisions (R. 560.101 et seq.), Condominium Development (R. 559.101 et seq.) and Mobile Home Park Development (R. 325.3311 et seq.). This review shall determine if current regulations include adequate measures to prevent state development that would cause the state to incur flood damages for floods up to and including a 100-year flood. The strategy shall recommend changes in the applicable regulations when necessary and appropriate to assure compliance with the State Flood Hazard Mitigation Plan.

4. A review of the provisions of the Single State Construction Code Act, Act No. 245 of the Public Acts of 1999, being Section 125.1501 et seq. of the Michigan Compiled Laws, and any administrative rules promulgated by CIS under the act (R. 408.30101 et seq.). This review shall determine if state development in floodplain areas complies with the provisions of the Act and the administrative rules adopted pursuant to the Act. The strategy shall recommend changes in the applicable regulations when necessary and appropriate to assure compliance with the State Flood Hazard Mitigation Plan.

5. The establishment of a coordination mechanism between DMB and DEQ to assure that the construction of buildings and other state facilities avoids the use of flood-prone lands whenever possible and to assure that new state facilities are designed to minimize potential flood damage when necessary and appropriate.

6. The preparation and implementation of an educational program for the general public and local units of government focusing on the need to reduce flood damages.

Flood damage prevention is of great importance to the safety, health and welfare of our citizens. I am confident that state departments and agencies can and will assist in the development of a more effective flood mitigation strategy and thereby minimize the likelihood that state property will be damaged during future flood events.

Thank you for your cooperation.

Attachment H (cont.):

STATE OF MICHIGAN
Executive Office * Lansing

EXECUTIVE ORDER 1977-4 (ELECTRONIC COPY)

STATE FLOOD HAZARD MITIGATION PLAN

WHEREAS, uneconomic uses of the State's flood plains are occurring and potential flood losses are increasing; and

WHEREAS, the State has extensive and continuing programs for the construction and reconstruction of buildings, roads, and other facilities and annually disposes of hundreds of land parcels that may be flood prone, all of which activities significantly influence patterns of commercial, residential, and industrial development; and

WHEREAS, State land use planning programs are determining factors in the utilization of lands; and

WHEREAS, the Federal Flood Disaster Protection Act of 1973 (P. L. 93-234) and the National Flood Insurance Program requires a state management plan;

NOW, THEREFORE, I, WILLIAM G. MILLIKEN, Governor of the State of Michigan, pursuant to the authority vested in me by the Michigan Constitution, laws of the State of Michigan, and the applicable provisions of P. L. 93-234, hereby order the following:

1. The Department of Natural Resources, Water Management Division is hereby designated as the state agency to supervise and administer the state flood hazard management program. Requests for information or technical assistance to implement the provisions of this Order shall be directed to the Water Management Division.

2. The heads of the State agencies shall provide leadership in encouraging a broad and unified effort to prevent uneconomic uses and development of the State's flood plains and, in particular, to lessen the risk of flood losses in connection with State lands and installations and State financed or supported improvements.

3. To implement this mandate, it is hereby ordered that:

    a) All State agencies directly responsible for the construction of State buildings, structures, roads, or other facilities shall evaluate flood hazards when planning the location of new facilities and, as far as practicable, shall preclude the uneconomic, hazardous, or unnecessary use of flood plains in connection with such facilities.

    b) With respect to existing State owned properties which have suffered flood damage or which may be subject thereto, the responsible agency head shall require conspicuous delineation of past and probable flood heights so as to assist in creating public awareness of the knowledge about flood hazards. Whenever practical and economically feasible, flood proofing measures shall be applied to existing facilities in order to reduce flood damage potential.

    c) All State agencies responsible for the disposal of State lands or properties shall evaluate flood hazards in connection with lands or properties proposed for disposal to non-State public

instrumentalities or private interests and, as may be desirable in order to minimize future public expenditures for flood protection and flood disaster relief and as far as practicable, shall attach appropriate restrictions with respect to uses of the lands or properties by the purchaser and his successors and may withhold such lands or properties from disposal.

d) All State agencies responsible for programs which entail land use planning shall take flood hazards into account when evaluating plans and shall encourage land use appropriate to the degree of hazard involved.

4. All flood hazard evaluations shall be based upon a base flood that has a 1% chance of being equaled or exceeded in any given year, commonly known as a 100-year flood.

5. Proposals for new construction, substantial improvements or other developments or alteration within a flood hazard area shall be guided by the following standards:

a) Encroachments within the floodway of a stream that would result in any increase in flood stage shall be prohibited unless approved by the Department of Natural Resources.

b) All new construction and substantial improvements shall have the lowest floor (including basement) elevated to or above the base flood level. Non-residential construction may be designed with attendant utility and sanitary facilities so that below the base flood level, the structure is watertight with walls substantially impermeable to the passage of water and with structural components having the capacity of resisting hydrostatic and hydrodynamic loads and effects of buoyance. Any utilization of flood proofing techniques shall require a certification from a registered engineer or architect that the flood proofing methods are adequate to withstand the flood depths, hydrostatic pressures, velocities, impact, and uplift pressures associated with the base flood. All certificates indicating the elevation at mean sea level datum to which such structures are flood proofed shall be kept on record within the State agency responsible for the structure.

6. Requests for appropriations for State construction of new buildings, structures, roads, or other facilities shall be accompanied by a statement by the head of the agency on the findings of his agency's evaluation and consideration of flood hazards in the development of such requests. If the construction is in a flood prone area, the statement shall contain a letter of non-objection from the Department of Natural Resources.

7. The State agencies shall proceed immediately to develop such procedures, regulations, and information as are provided for in, or may be necessary to carry out, the provisions of this Order.

Given under my hand and the Great Seal of the State of Michigan this Thirteenth day of May in the Year of Our Lord, One Thousand Nine Hundred and Seventy-Seven and of the Commonwealth One Hundred Forty-One.

(signed by William G. Milliken)
GOVERNOR

BY THE GOVERNOR:

(signed by Richard H. Austin)
Secretary of State

Mitigation Strategies for Federally Declared Disasters:

Federal Disaster #4121: 2013 Central and Southern Michigan Flooding
Federal Disaster #1777: 2008 Severe Storms and Flooding
Federal Disaster #1527: 2004 Southern Michigan Severe Storms and Flooding
Federal Disaster #1413: 2002 Central and Western Upper Peninsula Flooding
Federal Disaster #1346: 2000 Detroit Area Urban Flooding
Federal Disaster #1237: 1998 Detroit Area Windstorm
Federal Disaster #1226: 1998 West Michigan Windstorm
Federal Disaster #1181: 1997 Southeast Michigan Tornadoes and Flooding
Federal Disaster #1128: 1996 East Michigan Tornado and Flooding
Federal Disaster #1028: 1994 Northern Michigan Deep Freeze
Federal Disaster #774: 1986 Central Michigan Flooding

Hazard Mitigation Strategy for Federal Disaster #4121: 2013 Central and Southern Michigan Flooding

Joint Hazard Mitigation Strategy
4121-DR-MI

July 24, 2013

DECLARATION

On June 18, 2013, President Barack Obama issued a Major Presidential Disaster Declaration (4121-DR-MI) for the State of Michigan resulting in federal disaster assistance to eligible applicants in sixteen counties designated for FEMA Public Assistance (PA) for flood damage that occurred between April 16 and May 14, 2013, and for Hazard Mitigation (HM) assistance throughout the state. The designated counties are Allegan, Baraga, Barry, Gogebic, Houghton, Ionia, Kent, Keweenaw, Marquette, Midland, Muskegon, Newaygo, Ontonagon, Osceola, Ottawa, and Saginaw Counties. Hazard Mitigation Grant Program (HMGP) assistance was declared state wide. On June 29, 2013, a FEMA/Michigan Joint Field Office (JFO) was established in Kentwood (Kent County), and declared operational as of July 1, 2013

BACKGROUND OF EVENT

Beginning on April 16, 2013, a low pressure system moved eastward across the Great Lakes, bringing showers, thunderstorms, and three to five inches of rain to various parts of Michigan. On April 18, 2013 at 10:30pm, approximately 26,858 customers in Michigan were without power, reaching a 24-hour peak of 76,519 customers without power. The rain continued into Friday April 19, 2013, with a two-day precipitation total of five inches. Substantial rises in river levels across Michigan resulted from this rainfall and rapidly melting snow, particularly in western portions of the Upper Peninsula, where the frozen ground prevented precipitation and melting snowpack from being absorbed, exacerbating the event.

Numerous flood warnings were issued in the State of Michigan, specifically in the west and central portions of the state. Six counties and several cities issued Emergency Declarations. No mandatory evacuations were implemented, but numerous voluntary evacuations did occur across the State.

Some rivers continued to rise above record flood levels causing the counties to take emergency actions. The Grand River in the Grand Rapids area surged to historic levels and sandbagging operations were required for protection. The Grand River crested in the evening of April 21, 2013, in downtown Grand Rapids and Comstock Park. Around 10:00 pm it peaked at 21.85 feet in downtown Grand Rapids, breaking the record of 19.64 feet set in 1985. In Comstock Park, the river crested at 17.8 feet around the same time, surpassing the 65-year-old record of 17.75 feet set in 1948. Businesses and building owners along the river shored up their properties as much as possible and local officials had to close the Fulton Street Bridge because of a high-voltage power line threatened by the rising river. Although most rivers began to recede during the following week, there were some lingering floodwaters that continued to affect various areas of the state.

The event was determined to be beyond the capabilities of the State and the affected local governments. Governor Rick Snyder submitted a request to the President on June 7, 2013, to declare a major disaster for the State of Michigan. This request was responded to with the disaster declaration described above.

PURPOSE

This Hazard Mitigation Strategy identifies objectives and actions describing how mitigation activities will be accomplished. The tasks listed here are consistent with the Michigan Hazard Mitigation Plan and will be implemented as needed to achieve the desired results.

STRATEGIC GOALS

HM goals and objectives have been established for this disaster and are based on the current Michigan Hazard Mitigation Plan and the priorities of the State Coordinating Officer (SCO) and Federal Coordinating Officer (FCO), as follows:

GOAL 1:	Support efforts to update state and local (HM) plans where these plans have expired or are nearing expiration, and support efforts to complete plans in local communities that do not yet have them
GOAL 2:	Assist the State and local communities in promoting and successfully implementing hazard mitigation projects
GOAL 3:	Promote effective Floodplain Management through community education, outreach and training, and the provision of technical assistance to the State
GOAL 4:	Provide support and advocacy to Public Assistance (PA) to ensure the implementation of Section 406 HM measures on all appropriate PA projects.

RESOURCE AND STAFFING

Mitigation staffing for this disaster will be composed of limited JFO staff and Regional/State support staff who have been working virtually out of the FEMA Region V Chicago office and the Michigan State Police Emergency Management and Homeland Security Division (MSP/EMHSD) in Lansing. A satellite JFO has opened in Negaunee. Anticipated JFO staffing needs include an HM Group Supervisor to serve as the Mitigation Branch lead, two (2) Hazard and Performance Analysis (HPA) Specialists, a Best Practices Writer, and an Insurance Specialist. The Region V mitigation point of contact for this disaster had initially been deployed to initiate operations, ensure close coordination with the State, and finalize the Hazard Mitigation Strategy. Virtual support will be used for Hazard Mitigation Grant Program coordination, planning technical assistance, floodplain management technical assistance, and Section 406 HM technical assistance. All training identified in this Strategy will be implemented by Region V staff in conjunction with designated State personnel, and will require short deployments directly to the training locations. HM support will be focused on the declared counties due to limited resources.

HAZARD MITIGATION OBJECTIVES AND TASKS

I. HAZARD MITIGATION GRANTS AND PLANNING

Objective #1: Provide value-added technical assistance (actions coded A, D, F, and P below).

LINKS TO GOAL #1: Support efforts to update state and local hazard mitigation (HM) plans where these plans have expired or are nearing expiration, and support efforts to complete plans in local communities that do not yet have them. See below.

County	2010 Population	Plan Status	Expiration Date	Planning Grant?	Date of Grant	Type of Action
Allegan	111,408	Expired	4/25/2012	Yes	2012	D, F
Baraga	8,860	Expired	6/2/2011	Yes	2010	D, F
Barry	59,173	Expired	3/10/2011	No	N/A	P
Gogebic	16,427	Expired	6/2/2011	Yes	2010	D, F
Houghton	36,628	Expired	3/24/2011	Yes	2010	D, F
Ionia	63,905	No approved Plan	N/A	No*	N/A	A, D
Kent	602,622	Fully approved	5/22/2017	No	N/A	D
Keweenaw	2,156	Expired	4/19/2010	Yes	2010	D, F
Marquette	67,077	Expired	1/28/2013	Yes	2011	D, F
Midland	83,629	Fully approved	11/28/2013	No	N/A	D, F, P
Muskegon	172,188	Expired	6/2/2011	Yes	2011	D, F
Newaygo	48,460	Expired	6/30/2013	Yes	2011	D, F
Ontonagon	6,780	Expired	3/7/2011	Yes	2010	D, F
Osceola	23,528	No Approved Plan	N/A	No*	N/A	A, D
Ottawa	263,801	Fully approved	7/12/2017	No	N/A	D
Saginaw	200,169	Expired	5/27/2013	No	N/A	P

* MSP/EMHSD staff are providing direct assistance to these communities' planning efforts.

Key to "Type of Action" abbreviations:
A: State to provide direct planning assistance to help develop a local hazard mitigation plan for those communities not using planning grant funds.
D: Discuss potential hazard mitigation projects and grant application strategies.
F: Provide feedback to planning offices on their draft hazard mitigation plans/materials developed for the local communities.
P: Discuss planning grant application procedures and prospects.

Planning support will be a collaborative effort including training provided by qualified Region V Planning Specialists and the MSP Planning Specialists in Lansing. This work will emphasize remote methods of support (through the use of telecommunication technologies), with only limited travel expenditures for face-to-face meetings with communities, as the need arises.

Priority Tasks 1, 5, 21, 22, 23, have been selected by the State to be accomplished with support from FEMA. The remaining tasks will be scheduled as resources and time permits. The Priority Tasks are annotated with their description highlighted in gray.

TASK/ACTION	RESPONSIBLE AGENCIES	SCHEDULE	Task Number
(A, D) Provide technical assistance on Local Hazard Mitigation Planning. Outreach to potential HMGP sub-applicant communities whose HM plans have expired or will expire.	MSP/EMHSD; FEMA	Ongoing	1
Expedite any pending FEMA reviews of Local Hazard Mitigation Plans. (F)	FEMA	Ongoing	2
(P) The State may use up to 7% of HMGP funds for local hazard mitigation planning grants, and will assist communities with application development. FEMA will work with the State to expedite Local Hazard Mitigation Planning Grant awards.	MSP/EMHSD; FEMA	Ongoing	3
Coordinate with GIS to review and validate geospatial and attribute data for State-owned critical facilities.	FEMA/ Michigan Dept. of Technology, Management and Budget/MSP/EMHSD	On Going	4

Objective #2: Provide technical assistance to the State in the administration of HMGP.

LINKS TO GOAL #2: Assist the State and local communities in promoting and successfully implementing HM projects.

Grants Management training is an important task in support of HMGP under this disaster. Per the State's request, Region V certified trainers will present part of the full suite of HM Assistance courses. The courses are appropriate for State, local and FEMA personnel involved in applying for, reviewing, implementing or administering grants. These training opportunities will result in more complete HMGP applications and thus quicker review and approval. The timing of the courses will be determined in collaboration with the State to maximize attendance of the target audiences. The courses will generally be offered twice, once in the

Lower Peninsula and once in the Upper Peninsula, provided there is sufficient demand to warrant two separate sessions. Two FEMA Region V staff will deploy to teach each class.

TASK	RESPONSIBLE AGENCIES	SCHEDULE	TASK NUMBER
Resolve NEMIS access issue for the State, install most current NEMIS software, and provide refresher on NEMIS data entry	FEMA IT/FEMA HMA	July 2013	5
Coordinate the delivery of L276 Benefit Cost Analysis, a 2-day training session for local community, State and FEMA staff.	FEMA; MSP/EMHSD	TBD	6
Coordinate the delivery of L212 Unified Hazard Mitigation Assistance (HMA): Developing Quality Application Elements, a 3-day training session for local community, State and FEMA staff.	FEMA; MSP/EMHSD	TBD	7
Coordinate the delivery of L214 Unified HMA: Project Implementation and Programmatic Closeout, a 2-day training session for local community, State and FEMA staff.	FEMA; MSP/EMHSD	TBD	8
Provide technical assistance to State and local communities regarding Sandy Reform and Improvement Act (SRIA) policy changes and HMA Guidance.	MSP/EMHSD; FEMA	Ongoing	9
Solicit and review HMGP pre-applications.	MSP/EMHSD	Ongoing	10

TASK	RESPONSIBLE AGENCIES	SCHEDULE	TASK NUMBER
Update HMGP State Administrative Plan to reflect current policies and procedures and to ensure compliance with 206.437 for DR-4121-MI.	MSP/EMHSD	July 2013	11
FEMA review and approval of HMGP State Administrative Plan	FEMA	July 2013	12
Provide State with an initial estimate of Management Costs in accordance with 44 CFR 207.	FEMA	July 2013	13
Coordinate with GIS to review and validate geospatial and attribute data for State-owned critical facilities.	FEMA/ Michigan Department of Technology, Management and Budget/MSP/EMHSD	On Going	14

II. FLOODPLAIN MANAGEMENT AND INSURANCE

Objective #1: Provide technical assistance to the State relating to floodplain management and insurance.

LINKS TO GOAL #3: Promote effective Floodplain Management through community education, outreach and training, and the provision of technical assistance to the State.

An Insurance Specialist will deploy to the JFO for approximately three weeks to complete these tasks. This person will also be a resource for answering flood insurance questions that arise at the JFO.

One Region V staff member will deploy directly to the field to conduct training sessions in up to eight locations throughout Michigan. The locations and dates will be coordinated with Michigan Department of Environmental Quality (MDEQ).

TASK	RESPONSIBLE AGENCIES	SCHEDULE	TASK NUMBER
Identify and contact non-participating and sanctioned communities using letters and materials that encourage participation in the NFIP	FEMA	July 2013	15
Write letters to affected communities on Substantial Damage provisions.	FEMA	July 2013	16
Provide outreach to insurance agents to promote a better understanding of the NFIP	FEMA	July 2013	17
Provide outreach to Tribes in Michigan to promote hazard mitigation plans and NFIP participation.	FEMA	July 2013	18
Provide two advanced floodplain training modules: Post-disaster Responsibilities, and Substantial Improvement, Substantial Damage to MI Districts.	MDEQ/FEMA	July – August 2013	19
Encourage local officials from declared counties to participate in Emergency Management Institute course, *L273: Managing Floodplain Development Through the National Flood Insurance Program*.	MDEQ/FEMA	July – August 2013	20

III. COMMUNITY EDUCATION AND OUTREACH (CEO)

Objective #1: Develop and Disseminate Hazard Mitigation Success Stories for Stakeholder Outreach on the efficacy of coordinated mitigation planning.

LINKS TO GOAL #1: Support efforts to update state and local hazard mitigation (HM) plans where these plans have expired or are nearing expiration, and support efforts to complete plans in local communities that do not yet have them.

LINKS TO GOAL #2: Assist the State and local communities in promoting and successfully implementing HM projects.

The development and dissemination of HM success stories is identified as an objective in the Michigan Hazard Mitigation Plan (HM objective 4.12, p. 600). That objective includes the eventual update of Publication 106a, Michigan Hazard Mitigation Success Stories, which currently documents their mitigation successes from 1998 through 2011.

A Community Education & Outreach (CEO) writer will be deployed to document hazard mitigation success stories the State has identified, including several storm water management projects in the declared disaster area that are reported to have performed well during the April/May 2013 floods. The stories will be published in the FEMA best practices library and in the second edition of the MSP/EMHSD Publication 106a, Michigan Hazard Mitigation Success Stories (located on the MSP/EMHSD website). The State will also use these products for public information purposes, in presentations and other forms of training, and for consideration in updates of the Michigan Hazard Mitigation Plan.

TASK	RESPONSIBLE AGENCIES	SCHEDULE	TASK NUMBER
Develop best practice stories on successful projects in the declared disaster area.	FEMA; MSP/EMHSD	August 2013	21

IV. HAZARD PERFORMANCE and ANALYSIS (HPA)

Objective #1: Promote effective HM through quantitative analysis of past projects.

LINK TO GOAL #2: Assist the State and its local communities in promoting and successfully implementing HM projects.

HPA will utilize quantitative methodology to produce a loss avoidance report concerning completed mitigated properties. This report will demonstrate the value inherent in flood mitigation involving either elevation or acquisition of flood-prone structures. MSP has

identified several projects in the declared area to investigate for inclusion in the study: Robinson Township, Ottawa County (9 homes acquired); Plainfield Township, Kent County (9 homes acquired); City of Wyoming, Kent County (3 homes acquired); and Ada Township, Kent County (1 home acquired). A FEMA Reservist will be deployed to complete this task.

TASK	RESPONSIBLE AGENCIES	SCHEDULE	TASK NUMBER
Develop loss avoidance reports for identified communities in the declared area using Region V benefit-cost methodology.	FEMA; MSP/EMHSD	August 30, 2013	22

Objective #2: Provide technical assistance to the State as required regarding the application of Section 406 mitigation measures on PA projects.

LINKS TO GOAL #4: Provide support and advocacy to PA to ensure the implementation of Section 406 HM measures on all appropriate PA projects

TASK	RESPONSIBLE AGENCIES	SCHEDULE	
Provide 406 technical assistance and/or training, upon request, to maximize hazard mitigation opportunities	FEMA	Ongoing	23
Provide limited support for event frequency assessments (primarily of rural streams) at the request of PA , to assist BCA computations	FEMA; MDEQ USGS	August-September 2013	24

SUMMARY

The hazard mitigation objectives and tasks identified in this Hazard Mitigation Strategy will be implemented through a robust FEMA/State partnership dedicated to preventing loss of life and property to the residents of Michigan. JFO staff will be augmented with Region V staff and the functions included in this strategy will ultimately be transferred to FEMA Region V. Depending on the needs of its State partners, all tasks identified but not completed prior to the demobilization of the Mitigation Branch will transition back to the State or Region for oversight and monitoring.

Hazard Mitigation Working Group

Matt Schnepp	MSP/EMHSD	State Hazard Mitigation Officer
Joel Pepper	MSP/EMHSD	Assistant State Hazard Mitigation Officer
Doran Duckworth	MSP/EMHSD	State Support Unit Manager / State Planner
Mike Sobocinski	MSP/EMHSD	Hazard Mitigation Planner
Mitch Graham	MSP/EMHSD	Hazard Mitigation Planner
Les Thomas	Michigan DEQ	State NFIP Coordinator
Byron Lane	Michigan DEQ	Chief, Hydrologic Studies & Dam Safety Unit
Catrina Covino	FEMA RV	HM FPM&I Specialist
Ken Hinterlong	FEMA RV	HM HPA Specialist
Rick Foody	FEMA RV	HM Grants Specialist
Kirstin Kuenzi	FEMA RV	HM Planner
Ray Morgan	FEMA	HM Group Supervisor

Attachments

1. Declared Counties Map and program availability for the disaster

Mark Neveau

Mark Neveau
Federal Coordinating Officer
FEMA-DR-4121-MI

7-25-13
Date

Chris A. KeOenobe

Capt. Chris Kelenske, State Coordinating Officer
FEMA-DR-4121-MI
Michigan Department of State Police
Emergency Management and Homeland Security Division

8/7/13
Date

Christine Stack

Christine Stack, Mitigation Division Director
U.S. Department of Homeland Security
FEMA Region V

7-29-13
Date

ATTACHMENT 1 - Declared Counties Map

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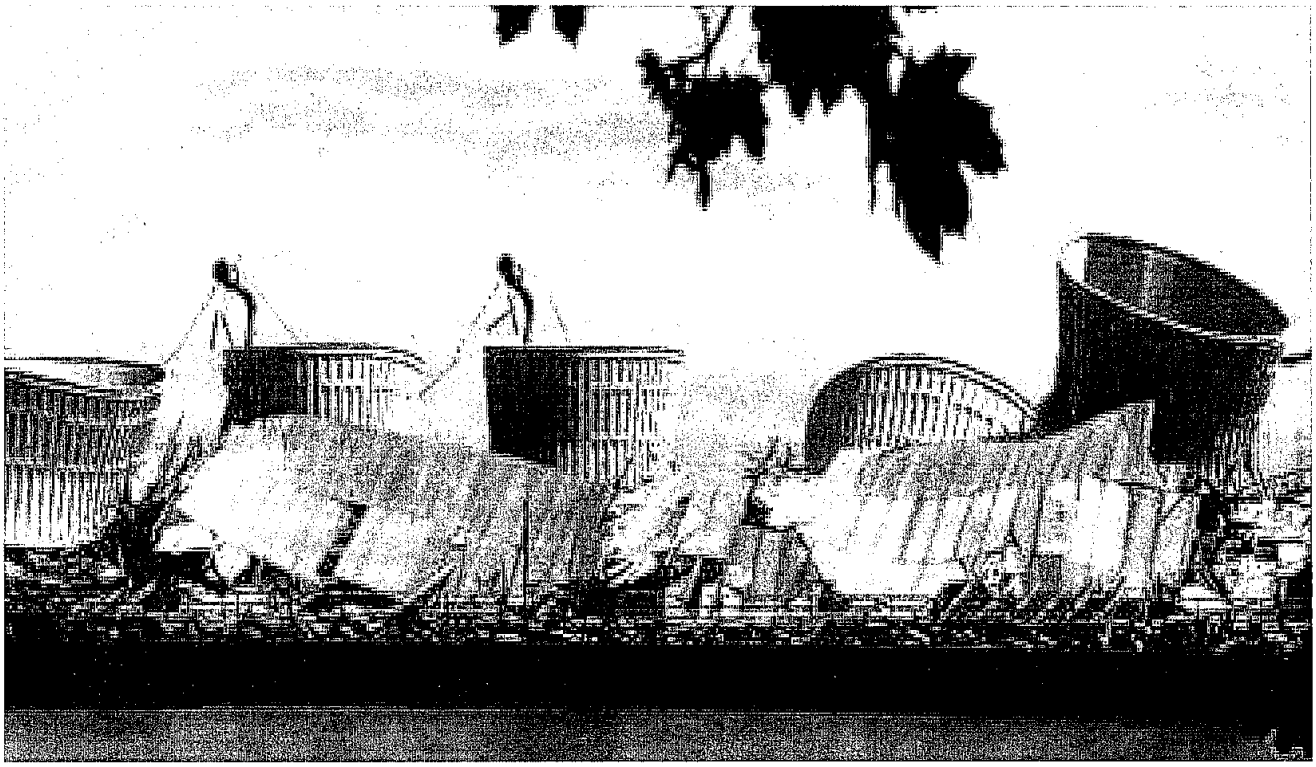
Hazard Mitigation Strategy for Federal Disaster #1777: 2008 Severe Storms and Flooding



FEMA-1777-DR-MI

Mitigation Action Plan

Declared July 14, 2008 for Allegan, Barry, Eaton, Ingham, Lake, Manistee, Mason, Missaukee, Osceola, Ottawa, and Wexford County in the State of Michigan

FEMA

Michigan State Police
Emergency Management and
Homeland Security Division

Mitigation Action Plan
OBJECTIVES AND PRIORITIES
FEMA-1777-DR-MI
Declared July 14, 2008

Background of Storm Event

Beginning on June 6, severe weather impacted twelve counties and two major population centers in southwest and central Michigan. Impacted counties include Allegan, Barry, Eaton, Ingham, Lake, Manistee, Mason, Missaukee, Osceola, Ottawa, Saginaw and Wexford. The National Weather Service in Grand Rapids reported two flash floods that exceeded the 100 year threshold, confirmed three F1 (73 – 112 mph) tornadoes, and severe thunderstorms with winds in excess of 100 mph. Rainfall totals were estimated between seven and twelve inches by the National Weather Service. Rainfall occurred in less than six hours exceeding the 100 year rainfall values of 3.5 inches in the affected area. Flash flooding washed out roads, flooded crops, and caused moderate flooding on local rivers and streams. Subsequently, this weather pattern produced additional severe weather that impacted the same counties. The NWS confirmed that three tornadoes impacted the area during this event. On June 8, a tornado with up to 100 mph winds formed over north-central Eaton County and moved into the west side of Lansing (Ingham County) before lifting. This tornado destroyed a cooling tower at a power plant in Ingham County and significantly damaged another one. Severe thunderstorm winds of up to 80 mph caused significant damage in East Lansing. A second tornado with winds of 100 mph occurred on the same day and tracked for about eight miles across Osceola County affecting Reed City and the Town of Evart. A third tornado touched down several times with winds of 100 mph in Mason and Manistee Counties on June 12, preceding flash flooding in the same areas. Severe thunderstorms produced wind bursts of 80 to 110 mph on June 6, 2008. On June 7, storms produced 80 to 100 mph downburst winds over two counties including the State Capitol building, and the City of Lansing. A large severe thunderstorm squall line affected all of the southwest Michigan on June 8, with four counties affected by squalls of 75 to 100 mph (see Attachment A).

On July 7, 2008, Governor Jennifer Granholm requested a Federal Major Disaster Declaration for the 12 affected counties within the State of Michigan. On July 14, 2008, President George W. Bush designated the following counties eligible for Public Assistance (PA) under FEMA-1777-DR-MI: Allegan, Barry, Eaton, Ingham, Lake, Manistee, Mason, Missaukee, Osceola, Ottawa, and Wexford and statewide eligibility for the Hazard Mitigation Grant Program (HMGP).

Mitigation Objectives and Priorities

The objective of mitigation is to reduce future disaster losses through acquisition and relocation of hazard-prone structures, structural retrofitting, mitigation education of community officials and residents, wise land use and development practices, prudent use of resources and funding, and encouragement of National Flood Insurance Program (NFIP) implementation and compliance, among other measures. Mitigation measures can also be implemented on public facilities through the use of Section 406 mitigation under the PA program.

This Hazard Mitigation Action Plan lists specific objectives and priorities that are divided into four categories: Hazard Mitigation Grant Program; Promotion of Section 406 mitigation through the PA Program; Promotion of Local Mitigation Planning; and Outreach/Best Practices.

Hazard Mitigation Grant Program

Michigan's priority for the HMGP is two-fold. First, the State would like to fund several projects that were not funded during the Fiscal Year 2008 grant cycle under the Pre-Disaster Mitigation (PDM) Program. These projects involve mitigation planning and activities to reduce future flood damages (such as acquisition and removal of flood prone structures from the floodplain). Supporting mitigation planning efforts and removing flood prone structures from floodplains is consistent with priorities in the Michigan State Hazard Mitigation Plan. Additionally, selecting these projects benefits the 1777-DR-MI HMGP in that the projects are already developed which will allow for quicker implementation of the program. The second State priority for the HMGP is to provide the declared counties and local communities with the opportunity to mitigate losses or potential future losses. If an insufficient number of eligible, cost-effective projects are identified within the affected counties to utilize the remaining funds, other applications from throughout the state will be considered for funding.

Mitigation opportunities within the declared area are of critical importance. Even though the projects outlined under the first priority may not be from the declared area, there are ample mitigation resources available to the declared counties. Prior to the initiation of the HMGP, declared counties will benefit from mitigation actions taken under the Section 406 mitigation under the PA program (which will be discussed later in this document). Also, the Fiscal Year 2009 Hazard Mitigation Assistance (HMA) application period is currently open. Applicants from the declared counties will be able to submit applications for funding under the various Hazard Mitigation Assistance programs (also discussed later in this document), likely in advance of the 1777-DR-MI HMGP open application period.

Given that a significant portion of the damage associated with 1777-DR-MI resulted from tornadoes, Michigan may choose to exercise the option to increase the HMGP five percent initiative to ten percent for tornado safety related projects, according to the Michael Armstrong Policy Memo dated August 18, 1998 (Attachment B). Ultimately,

the Michigan Citizen-Community Emergency Response Coordinating Council (MCCERCC) will determine priorities for the 1777-DR-MI HMGP funding and may elect to maximize the available funding for this group of projects.

The state does not plan on expediting the HMGP application process. HMGP processing will take place within the state and regional office. The state must submit its HMGP application within 12 months of the disaster declaration.

Action	Lead Agency	Date Due
Prioritize and select projects that meet the goals and requirements of the HMGP for 1) non-funded Fiscal Year 2008 PDM projects and 2) the declared counties 3) non-declared counties.	MSP	7/14/2009
FEMA will provide technical assistance on HMGP applications throughout the grant application cycle.	FEMA	7/14/2009
State mitigation staff will update the State Administrative Plan for 1777-DR-MI in accordance with new FEMA management cost rules.	MSP	9/30/2008
Brief the MCCERCC on the proposed HMGP strategy and seek approval of the proposed priorities.	MSP	8/19/2008

Hazard Mitigation Assistance Non-disaster Grant Programs

Under the Pre-Disaster Mitigation Program (PDM), Flood Mitigation Assistance program (FMA), Repetitive Flood Claim program (RFC), and Severe Repetitve Loss program (SRL) funding opportunities may be available to support mitigation efforts in the declared counties and elsewhere in the State of Michigan. The Michigan State Police Emergency Management and Homeland Security Division (MSP/EMHSD) will promote the program throughout the state and solicit applications. Applications will be reviewed and prioritized by the MSP/EMHSD and MCCERCC and forwarded to FEMA for funding consideration. Fiscal Year 2009 FEMA deadline for PDM grant applications is December 19, 2008.

Section 406 Mitigation Coordination with Public Assistance Program

Under the Robert T. Stafford Disaster Relief and Emergency Assistance Act, FEMA has the authority to fund the restoration of eligible public facilities that have sustained damages due to a Presidentially declared disaster. In Region V, Public Assistance is the lead division for all Section 406 mitigation measures but the Mitigation Division will support all PA 406 mitigation opportunities within the declared areas. Section 406 of the Stafford Act contains a provision for the consideration of funding additional measures that will enhance a facility's ability to resist similar damage to future events. The mitigation measures must be related to eligible disaster-related damages and must directly reduce the potential for future, similar disaster damages to the eligible facility. Mitigation measures must be determined to be cost-effective through any of these three measures: 1) mitigation measures may be to up to 15 percent of the total eligible cost of the repair work on a particular project; 2) certain mitigation measures have been determined to be cost effective, as long as the mitigation measure does not exceed 100 percent of the eligible cost of the repair work on the project; or 3) for measures that exceed the above costs, a FEMA approved benefit/cost module may be used. Michigan would like to promote Section 406 mitigation on every Project Worksheet where there is an opportunity.

Action	Lead Agency	Date Due
Promotion of Section 406 mitigation throughout affected counties through community outreach at Applicant Briefings and community questions to lead agencies	MSP/FEMA	ongoing
The Mitigation Branch will provide technical guidance to the PA Branch as requested for Section 406 Mitigation Issues	FEMA	ongoing

Promotion of Local Hazard Mitigation Planning

The State Standard Hazard Mitigation Plan was approved on March 27, 2008. The State is eligible to receive HMGP funds based on 15 percent of the total estimated eligible Stafford Act disaster assistance. The Governor has requested that the HMGP be made available statewide. Local communities can choose to participate within a multi-jurisdictional plan or county plan. After FEMA approval, each community within the multi-jurisdictional plan must adopt the plan before they are eligible for HMGP project grants. Within the 11 declared counties, 7 counties (Allegan, Barry, Eaton, Ingham, Mason, Missaukee, and Ottawa) have approved and adopted local mitigation plans, 3 counties (Lake, Manistee, and Wexford) have plans that meet requirements but either have never been formally adopted or have been adopted with documentation submission and FEMA acceptance still in process, and 1 county (Osceola) has a plan that has been in revision since 2005 (See Attachment C). Counties in Attachment C can be listed in both the approved and adopted category and the plans pending adoption category depending on whether the local communities have adopted the multi-jurisdictional county plan.

Action	Lead Agency	Date Due
Promote adoption of Local Mitigation Plans (LMP) in affected communities that meet requirements but have not been formally adopted through community outreach	MSP	12/31/2008
Promote adoption of LMPs throughout State of Michigan	MSP	12/31/2008
Analyze the necessity of updates to LMPs in counties with plans expiring within the next two years	MSP	12/31/2008
Meet with Osceola County to facilitate the completion of their local hazard mitigation plan.	MSP	8/1/2008
Provide technical / direct planning assistance to Osceola County, as required, to aid in the completion of a federally-approvable and DMA 2000 compliant hazard mitigation plan for the county.	MSP	12/31/2008

Outreach/Best Practices

When disasters occur, local officials and citizens have heightened awareness of the need to protect people and property from devastating losses. By highlighting how mitigation can provide additional protection against future risk and losses, individual citizens, businesses, and government leaders may be inspired to take positive action. Outreach activities and the promotion of mitigation "best practices" can increase awareness and enhance the likelihood of the success of mitigation measures.

Action	Lead Agency	Date Due
Coordinate mitigation activities with on-going External Affairs Outreach Program	FEMA	On-going
Document success stories, as requested by the state, to promote mitigation activities.	FEMA	12/15/2008

National Flood Insurance Program (NFIP) Coordination

The FEMA Floodplain Management and Insurance Branch (FM&I) and the Michigan Department of Environmental Quality (MDEQ) coordinated to determine the appropriate level of NFIP field-driven tasks. Given the nature of the event, subsequent preliminary damage assessments, and the delineated floodplains within the declared counties an agreement was reached that adequate follow-up could be achieved through combined efforts directed from the respective Federal and State offices. FM&I and MDEQ will support disaster activities through existing networks with no staff deployment at the Joint Field Office or participation in the Mitigation Action Plan.

Mitigation Action Plan Team Members

State of Michigan:
Doran Duckworth
State Support Unit Manager and State Planner

Matt Schnepp
State Hazard Mitigation Officer

Joel Pepper
Assistant State Hazard Mitigation Officer

Mike Sobocinski
Hazard Mitigation Planner

Federal Emergency Management Agency:
Norbert Schwartz
Mitigation Division Director

Anna Pudlo
Hazard Mitigation Assistance Branch Chief

Nicholas Mueller
Hazard Mitigation Officer

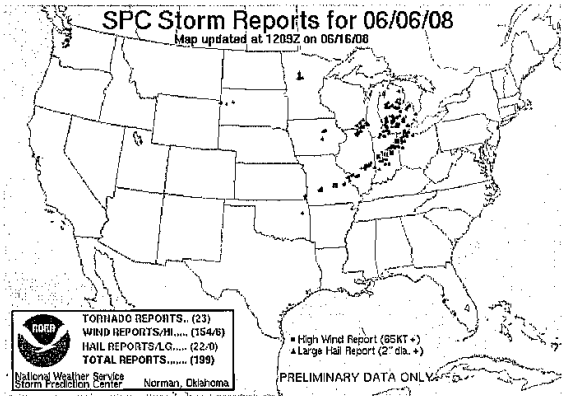
Heidi Kirkman
Hazard Mitigation Officer

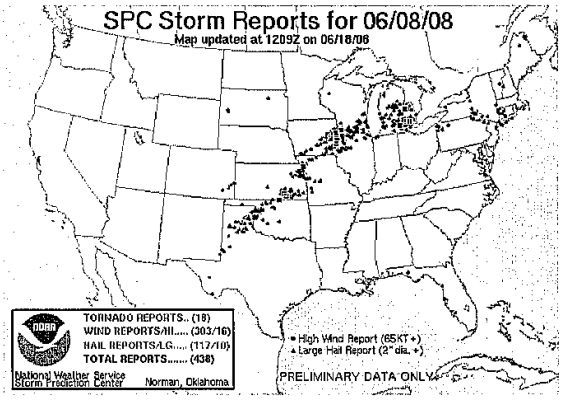
William Moore
Federal Coordinating Officer

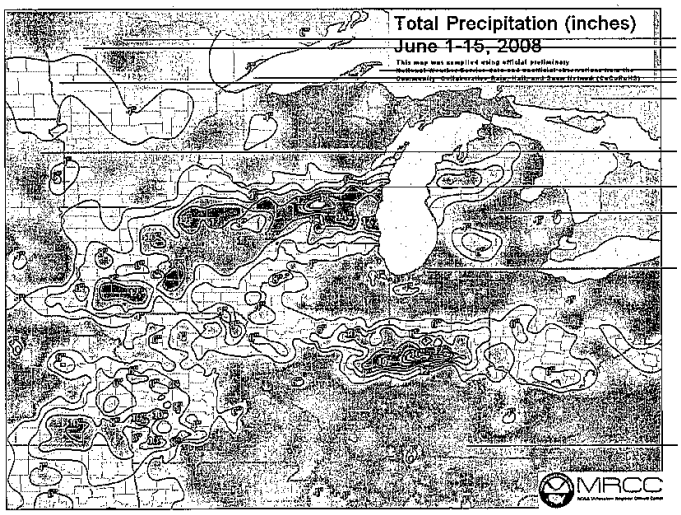
Ralph Hohrat FOR APK
Anthony P. Katarsky
State Coordinating Officer

Photo on Cover- 6/08/2008 Lansing, Michigan- Storm damaged cooling towers at the Board of Water and Light's Eckert's Power Station near Moore's River Drive. Lansing State Journal.

Attachment A
NOAA Weather Reports for Incident Period 6/6/2008 – 6/13/2008







Attachment B

Federal Emergency Management Agency

File

Washington, D.C. 20472

AUG 18 1998

EL-19

MEMORANDUM FOR: Regional Directors
Regions I-X

ATTENTION: Mitigation Division Directors

FROM: Michael J. Armstrong
Associate Director for Mitigation

SUBJECT: Use of Hazard Mitigation Grant Program (HMGP) for Measures to address Tornado Safety

The high incidence of tornadic activity associated with the 1997/1998 El Nino weather pattern has led to unusual loss of life and property damage. These recent disasters have made apparent the need for additional funding for warning systems that cannot be accommodated by existing programs.

While the Federal government cannot indefinitely support warning system acquisition, I want to be responsive to these unusual needs and I will allow States that have received a Presidential disaster declaration for tornadoes to use up to 10% of the total available HMGP funding, at their discretion, for hazard mitigation measures to address the unique hazards posed by tornadoes. This policy essentially increases the 5% set-aside initiative funding by an additional 5% to allow for tornado-related projects.

To qualify, States must develop a comprehensive plan to address warning of citizens (ensuring 90% coverage), furthering the "safe room" concept in construction or rehabilitation of residences or commercial structures, and address the issue of sheltering in mobile home parks. The plan must also have a component addressing how the State will implement an ongoing public education program so that citizens are aware of warning systems and their meaning (including the availability of in-home shelter designs).

FEMA also encourages the use of the NOAA weather radio system as a reliable and cost-effective means of providing timely warning to the public. Additionally, NOAA has agreed to maintain transmission points. Maintenance of warning systems will not be an eligible expense.

As with standard HMGP projects, a project type to be funded from the 10% portion of the HMGP must be identified in the State's hazard mitigation plan and fulfill the goal of the program, that is, to reduce or prevent future damage to property and to reduce or prevent loss of life or injury from tornadoes. However, tornado mitigation projects or measures, such as warning systems, eligible within this 10% portion of the HMGP are often difficult to evaluate against traditional quantitative program cost effectiveness and eligibility criteria. Consequently, in lieu of a benefit-cost analysis, the State should include a narrative that identifies the

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mitigation benefits and indicates that there is a reasonable expectation that future damage or loss of life or injury will be reduced or prevented. Finally, these projects will have to be reviewed for compliance under the National Environmental Policy Act and other federal environmentally-related laws.

In the interest of expediting the closeout of older disasters, this policy applies to all open disasters of any kind declared prior to Fiscal Year 1998. It also applies to all Fiscal Year 1998 and future declarations in which tornadoes or high winds played a role. This policy will terminate upon FEMA's adoption of HMGP regulatory changes published as a proposed rule in the Federal Register on May 1, 1998, which states that warning systems may only be funded from the 5% Initiative. We anticipate that this rule will be finalized by the end of the calendar year. New disaster declarations after the effective date of the Final Rule will operate under the original 5% Initiative guidelines.

Attached for your convenience is a sample letter conveying this policy to the State Directors. If you have any questions, please call Robert F. Shea at (202) 646-3619 or Donna M. Dannels at (202) 646-3662.

Attachment

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Attachment C
Local Mitigation Plan Status

Approved and Adopted	Plans Pending Adoption	Plans in Revision
Allegan County	**Allegan County**	**Osceola County**
Allegan County	Allegan, City	
Dorr Township	Casco Township	
Douglas, City of	Cheshire Township	
Laketown Township	Fennville, City of	
Monterey Township	Fillmore Township	
Otsego, City of	Ganges Township	
Overisel Township	Gun Plain Township	
Salem Township	Heath Township	
Saugatuck, City	Holland, City of	
Saugatuck Township	Hopkins Township	
Watson Township	Hopkins, Village	
Barry County	Lee Township	
Barry County	Leighton Township	
Hastings, City of	Manlius Township (sanctioned)	
Hope Township	Martin Township	
Thornapple Township	Martin Village	
Eaton Co.	Otsego Township	
Bellevue Township	Plainwell, City of	
Benton Township	Trowbridge Township	
Brookfield Township	Valley Township	
Carmel Township	Wayland City of	
Chester Township	Wayland Township	
Delta Township	**Barry County**	
Eaton Township	Assyria Township	
Eaton Rapids Township	Baltimore Township	
Hamlin Township	Barry Township	
Kalamo Township	Cariton Township	
Lansing City of	Castleton Township	
Roxand Township	Freeport, Village of	
Sunfield Township	Hastings Township	
Vermontville Township	Irving Township	
Walton Township	Johnstown Township	
Ingham County	Maple Grove Township	
Lansing, City of	Middleville, Village of	
Mason County	Nashville, Village of	
Mason County	Orangeville Township	
Amber Township	Prairieville Township	
Branch Township	Rutland Charter Township	
Custer Township	Woodland, Village of	
Custer, Village of	Woodland Township	
Eden Township	Yankee Springs Township	

Fountain, Village of
Free Soil Township
Free Soil, Village of
Hamlin Township
Ludington, City of
Meade Township
Pere Marquette Township
Riverton Township
Scottville, City of
Sheridan Township
Sherman Township
Summit Township
Victory Township

Missaukee County

Ottawa County

Ottawa County
Chester Township
Ferrysburg, City of
Grand Haven Township
Grand Haven, City of
Holland Township
Hudsonville, City of
Jamestown Township
Polkton, Charter Township
Port Sheldon Township
Wright Township
Zeeland, City of

Eaton County

Bellevue, Village of
Charlotte, City of
Dimondale, Village of
Eaton Rapids, City of
Grand Ledge, City of
Mulliken, Village of
Olivet, City of
Oneida Township
Potterville, City of
Sunfield, Village of
Vermontville, Village of
Windsor Township

Ingham County

Alaiedon Township
Aurelius Township
Bunker Hill Township
Dansville, Village of
Delhi Township
East Lansing, City of
Ingham Township
Lansing Township
Leroy Township
Leslie Township
Leslie, City of
Locke Township
Mason, City of
Meridian Township
Onondaga Township
Stockbridge Township
Stockbridge, Village of
Vevay Township
Webberville, Village of
Wheatfield Township
White Oak Township
Williamston Township
Williamston, City of

Lake County

Baldwin, Village of
Chase Township
Cherry Valley Township
Dover Township
Eden Township
Elk Township
Ellsworth Township
Lake Township
Luther, Village of
Newkirk Township
Peacock Township
Pinora Township

Pleasant Plains Township
Sauble Township
Sweetwater Township
Webber Township
Yates Township

Manistee County

Manistee County
Arcadia Township
Bear Lake Township
Bear Lake, City of
Brown Township
Cleon Township
Copemish Township
Dickson Township
East Lake, village
Filer Township
Kaleva, Village
Manistee Township
Manistee, City of
Maple Grove Township
Marilla Township
Norman Township
Onekama Township
Onekama, City of
Pleasanton Township
Springdale Township
Stronach Township

Mason County

Logan Twp (Suspended Community)

Missaukee County

Aetna Township
Bloomfield Township
Butterfield Township
Caldwell Township
Clam Union Township
Enterprise Township
Forest Township
Holland Township
Lake City, City
Lake Township
McBain, City
Norwich Township
Pioneer Township
Reeder Township
Richland Township
Riverside Township
West Branch Township

Ottawa Co

Allendale, Charter Township
Blendon Township

Coopersville, Village of
Crockery Township
Georgetown Township
Holland, City of
Olive Township
Park Township
Robinson Township
Spring Lake Township
Spring Lake, Village of
Tallmadge Township
Zeeland, Charter Township

Wexford County

Antioch Township
Boon Township
Buckley, Village of
Cadillac, City of
Cedar Creek,Township
Cherry Grove Township
Clam Lake Township
Colfax Township
Greenwood Township
Hanover Township
Haring Township
Harrietta, Village of
Henderson Township
Liberty Township
Mesick, Village of
Selma Township
Slagle Township
South Branch Township
Springville Township
Wexford Township

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Hazard Mitigation Strategy for Federal Disaster #1527: 2004 Southern Michigan Severe Storms / Flooding

FEMA-1527-DR-MI

Hazard Mitigation Strategy

Declared June 30, 2004 for Barry, Berrien, Cass, Eaton, Genesee, Gladwin, Ingham, Ionia, Jackson, Kent, Livingston, Macomb, Mecosta, Muskegon, Oakland, Ottawa, Saginaw, Sanilac, Shiawassee, St. Clair, St. Joseph, Washtenaw and Wayne Counties in Michigan

MITIGATION STRATEGY - FEMA-1527-DR-MI
State of Michigan

OBJECTIVE

The objective of mitigation is to reduce future disaster losses through acquisition and relocation of hazard-prone property, structural retrofitting, mitigation education of community officials and residents, wise land use and land development practices, prudent use of resources and funding, and encouragement of National Flood Insurance Program (NFIP) implementation and compliance, to name just a few measures that have been successful. To assist communities in Michigan with mitigation efforts so that the environment is safer and has a reduced risk from disaster damage, the following objectives must be accomplished:

1. Mitigation opportunities will be identified, prioritized and selected for implementation:

   - The initial mitigation opportunities and recommendations identified during the damage assessment process in many of the affected communities include the following (not listed in any particular order):

     A. Acquisition and relocation or retrofitting and floodproofing (including elevation) of substantially damaged structures located in flood prone areas.
     B. Applying the best methods to properly anchor and/or elevate or flood proof fuel oil tanks or propane gas tanks at homes and businesses.
     C. Floodproofing roads, bridges, culverts and other public facilities located in floodplains or other floodprone areas.
     D. Armoring erosion prone stream banks to prevent sedimentation and to otherwise ensure maximum hydraulic capacity is maintained.
     E. Community outreach and education to promote flood proofing methods in residential and commercial structures, focusing on elevation and/or relocation of utilities and mechanical systems in basements or other vulnerable areas. Resource packets of information about flood mitigation will be put together and mailed out to 858 state and university libraries in Michigan. The information packets will be publicized by press release so that the public knows the information is available for review. Additionally, a FEMA flood proofing flyer will be posted on the Emergency Management Division web site with a link to additional information on FEMA's web site.
     F. Completion of all-hazard mitigation plans as required under the federal Disaster Mitigation Act of 2000.
     G. Retrofitting of public and private facilities to reduce future wind damage through the application of proper structural wind engineering measures or construction of "safe rooms" and shelters.
     H. Vegetation management, with an emphasis on the establishment and/or improvement of community urban forestry measures.
     I. Community outreach and education to promote wind resistant building practices, the construction of "safe rooms" and community shelters, and proper urban forestry techniques and practices. Resource packets of information about wind mitigation will be put together and mailed out to 858 state and university libraries in Michigan. The information packets will be publicized by press release so that the public knows the information is available for review.

2. Financial resources, including disaster assistance programs such as the HMGP, and funds from other state and federal programs, will be maximized:

   - If the minimum threshold for the Federal Highway Administration (FHWA) Emergency Relief Program is met, inspectors will make every effort to include appropriate mitigation measures in restoring damaged Federal-Aid roads and bridges.

   - Under the Small Business Administration (SBA) disaster loan program, low interest loans will be made available for repairs and mitigation upgrades to damaged structures.

   - Under the Natural Resource Conservation Service (NRCS) Emergency Watershed Protection Program, appropriate mitigation measures will be implemented to remove any and all threats (urgent and compelling) resulting from sudden watershed impairment. In addition, supplemental funding will be requested to implement appropriate mitigation measures at other damaged, impacted or threatened sites (not considered urgent and compelling) in the absence of funding under the FEMA Public Assistance Grant Program.

- Under the U.S. Army Corps of Engineers (USACE), Continuing Authorities Program (CAP) and other post-flood damage and shoreline erosion (Section 14) mitigation/protection authorities and programs, appropriate mitigation may be implemented to assist the affected local governments in reducing or eliminating future damage and impacts caused by flooding and/or shoreline erosion.

- At the State's discretion, up to seven percent (7%) of available HMGP funds will be earmarked to facilitate the development of local hazard mitigation plans in the declared disaster area and in other communities in the region.

- Under the HMGP, funds will be earmarked as appropriate to acquire / relocate substantially damaged structures located in flood prone areas.

- Under the Pre-Disaster Mitigation Program – Competitive (PDMP-C), funding opportunities may be made available to support mitigation efforts in the declared area and elsewhere throughout the State of Michigan. Once FEMA announces the combined FY04 and FY05 PDM-C, the EMD/MSP will promote the program throughout the state and solicit applications. Received applications will be reviewed by the EMD/MSP, prioritized and forwarded to FEMA for funding consideration.

- Under the Flood Mitigation Assistance Program (FMAP), funds will be made available to eligible applicants as appropriate (at the discretion of the State) to support mitigation planning as well as projects designed to acquire and demolish / relocate repetitive flood loss structures under the National Flood Insurance Program (NFIP).

- Voluntary organizations (i.e., Red Cross, Salvation Army, etc.) will be requested to provide (as appropriate and in keeping with their organizational mission) financial and other resources to promote and facilitate the implementation of mitigation measures in individual damaged homes.

3. Long-term mitigation will be ensured through comprehensive and prudent public health and safety measures (i.e., floodproofing utilities, mechanical systems, and fuel oil / propane tanks at residences and businesses), local building practices, and floodplain management.

STRATEGY

The mitigation strategy for promoting and achieving hazard mitigation in this disaster will be focused on the following areas (not listed in any particular order):

- Public health and safety measures.
- Coordination with the FEMA HMGP and ONA, the FHWA Emergency Relief Program, the NRCS Emergency Watershed Protection Program, and the USACE Advance Measures Program and other flood repair and mitigation authorities.
- Community administered floodproofing measures.
- Mitigation project development.
- National Flood Insurance Program promotion and flood hazard identification.
- Promoting disaster resistant communities through the Pre-Disaster Mitigation Program, Flood Mitigation Assistance Program, the NFIP Community Rating System, and through local mitigation plan development.
- Community mitigation education and outreach.

Public health and safety measures

- Assist community officials and residents in identifying appropriate floodproofing solutions for furnaces, water heaters, fuel oil and propane tanks, utilities and other mechanical systems that will ensure public health, safety and general welfare. FEMA Mitigation Disaster Assistance Employees (DAEs) can provide written guidance materials directly to individual homeowners through community outreach at Disaster Recovery Centers (DRCs), through the media, through the dissemination of information packets being made available at 858 Michigan libraries, or through other appropriate avenues. (8/31/04)

- Assist community officials and residents in identifying appropriate structural wind engineering and vegetation management solutions that will reduce future wind damage to homes, businesses and community facilities. FEMA Mitigation DAEs can provide written guidance materials directly to individual homeowners through community outreach at Disaster Recovery Centers (DRCs), through the media, through the dissemination of information packets being made available at 858 Michigan libraries, or through other appropriate avenues. (8/31/04)

- The MHMCC will meet on August 18, 2004 to discuss issues associated with this disaster and possible opportunities to mitigate threats to public health and safety through the grant programs administered by the EMD/MSP. The MHMCC has a

representative from the Michigan Department of Environmental Quality (MDEQ) floodplain management program. Public health and safety issues pertaining to the flood damages in individual homes and businesses related to this disaster can be discussed and suggestions taken from the MDEQ representative. The MHMCC has a representative from the Michigan Department of Natural Resources (MDNR), which administers the statewide urban forestry program. Public safety issues related to tree damage within public rights-of-way from this disaster can be discussed and suggestions taken from the MDNR representative. The MHMCC can also solicit suggestions pertaining to structural wind engineering measures from the Michigan Department of Labor and Economic Growth (MDLEG), which oversees the statewide implementation of the State Construction Code.

Coordination with the other active relief programs

THE FIRST TWO BULLETS OF THIS SECTION CONSTITUTED PART OF THE STATE'S ORIGINAL STRATEGY FOR THIS DISASTER. UNFORTUNATELY, DUE TO PROGRAM ISSUES AND CONSTRANTS, MITIGATION FUNDING UNDER THE INDIVIDUAL HOUSING PROGRAM, OTHER NEEDS ASSISTANCE (ONA) WAS NOT INCLUDED WITH THIS DISASTER. THEREFORE, THESE TACTICS WERE UNABLE TO BE CARRIED OUT. THEY ARE BEING LEFT IN THE STRATEGY FOR HISTORICAL PERSEPCTIVE WITH REGARD TO MICHIGAN'S STATE HAZARD MITIGATION PLAN.

- FEMA Mitigation DAEs will provide guidance to ONA applicants (through DRCs, the media and other appropriate avenues) that promotes mitigation measures for individual homes and businesses and specifies the types of measures that are potentially eligible for funding under the ONA (i.e., back flow prevention devices, sump pumps, etc.). (8/31/04)

- Coordinate with FEMA ONA inspectors to ensure that appropriate mitigation measures are allowed and specified for damaged homes. This is best achieved by the FCO placing a high priority on ONA mitigation activities and conveying that priority to inspectors in the field via the IA Inspection Services Coordinator. Inspectors in the field must be provided with appropriate guidance about eligible mitigation costs that should be included in inspection reports. The FEMA Deputy Coordinating Officer (FCO) for Mitigation should also review the ONA inspection report trends (i.e., the percent of all ONA applicants that have specified mitigation measures) to ensure that mitigation measures are being specified in all appropriate circumstances and for all appropriate types of damage. (7/30/04)

- Coordinate with FHWA inspectors to ensure that appropriate mitigation measures are being considered for damaged Federal-Aid roads and bridges being repaired under the FHWA Emergency Relief Program. This is best achieved by having the Michigan Department of Transportation (MDOT) Emergency Manager monitor and evaluate the decisions being made by FHWA inspectors in the field. If mitigation measures are not being considered, the FEMA Deputy FCO for Mitigation should contact the FHWA and request that mitigation be considered where appropriate and cost-effective. (8/31/04)

- Coordinate with NRCS inspectors to ensure that appropriate mitigation measures are being considered on all sites being restored under the NRCS Emergency Watershed Protection Program and other activated programs. This is best achieved by having state mitigation staff monitor and evaluate the decisions being made by NRCS inspectors in the field and central office program staff in Lansing. If mitigation measures are not being considered, the FEMA Deputy FCO for Hazard Mitigation should contact the NRCS and request that mitigation be considered where appropriate and cost-effective. (8/31/04)

- Coordinate with the U.S. Army Corp of Engineers (USACE) on the possible development of flood control projects within or benefiting the declared area. (8/31/04)

Community-administered floodproofing and structural retrofitting measures

- Invite communities to establish and administer a locally based floodproofing program that would provide public education on proper floodproofing techniques, and provide grants to individual home and business owners wishing to retrofit their structures to reduce future flood damage. This is best achieved by encouraging communities to develop such a program by participation in the local hazard mitigation planning process. Appropriate projects identified in the plan (or in some instances, for participation in 1527-DR-MI HMGP, FY04 FMAP, or FY04/05 PDM-C, before the plan is complete) may be proposed under future grant cycles of the HMGP, FMAP, and PDM-C. The program could be implemented and administered by an existing local department, such as the building, planning or public works department, who would be responsible for disbursing grants, monitoring work, providing technical assistance, and providing program status to the State. (8/31/04)

Note: floodproofing methods could include but are not limited to the following:

- ✓ Acquisition and demolition / relocation of floodprone structures.
- ✓ Elevation of floodprone structures above the base flood level (100-year flood).
- ✓ Elevation and secure mounting (as appropriate) of basement fuel oil tanks to prevent tank ruptures during flooding.
- ✓ Elevation and secure mounting (as appropriate) of backyard propane tanks to prevent tank ruptures during flooding.
- ✓ Installation of standpipes, sewer backflow (check) valves, or revised plumbing to include an ejector or sump pump for basements.
- ✓ Elevation of electrical system components including service panels, meters, switches, and outlets that may easily be damaged by floodwater.
- ✓ Elevation or relocation of HVAC equipment, water heater, and washer / dryer.

- Invite communities to establish and administer a locally based structural retrofitting program that would provide public education on proper wind engineering techniques and components, and provide grants to individual home and business owners wishing to retrofit their structures to reduce future wind damage. This is best achieved by encouraging communities to develop such a program by participation in the local hazard mitigation planning process. Appropriate projects identified in the plan (or in some instances, for participation in 1527-DR-MI HMGP, FY04 FMAP, or FY04/05 PDM-C, before the plan is complete) may be proposed under future grant cycles of the HMGP, FMAP, and PDM-C. The program could be implemented and administered by an existing local department, such as the building, planning or public works department, who would be responsible for disbursing grants, monitoring work, providing technical assistance, and providing program status to the State. (8/31/04)

Mitigation project development

Information from the PDA, the Michigan Hazard Mitigation Plan (MHMP) and local mitigation plans (completed or partially-completed), the NFIP, and other state agencies (with substantial development interests in the declared area) will be used to help identify the communities that should be contacted concerning the possibility of mitigation opportunities under the HMGP and other state and federal programs. (8/31/04)

- FEMA Mitigation DAEs will review the PDA damaged structure inventory to identify structures that may have been substantially damaged. Those structures will be (at the State's discretion) specifically targeted for mitigation assistance. (7/30/04)

- Acquisition of substantially damaged structures will be the top priority mitigation project type under the HMGP for this disaster. Based on information provided by local units of government on substantially damaged structures, state mitigation staff and/or FEMA Mitigation DAEs will coordinate with communities to determine interest in the HMGP and, where appropriate, help to develop project applications for acquisition of substantially damaged structures. The MHMCC and state mitigation staff will immediately review and evaluate proposed mitigation projects for the acquisition of substantially damaged structures and submit them to FEMA for funding consideration under the HMGP for this disaster. (8/31/04)

- The MHMCC will coordinate with the Michigan Economic Development Corporation, the Michigan State Housing Development Authority, and other appropriate state agencies concerning communities with a substantial investment of state financial resources, in order to determine if additional mitigation partnering opportunities are available. (Ongoing)

- Whenever possible, mitigation projects will be incorporated into larger, ongoing or planned community projects (as long as the larger project will be completed in a timely manner and mitigation benefits can be fully retained). (Ongoing)

- Upon identification of communities particularly suitable for mitigation, federal and state time and resources permitting, local officials will be contacted to determine the level of local interest in developing a partnership to reduce the community's future risk from flooding and severe storms. FEMA Mitigation DAEs and/or state mitigation staff will conduct site visits with interested communities, at the State's discretion and within available personnel resources, to gain commitment in developing projects and implementing appropriate mitigation measures. The DAEs and/or state mitigation staff will function as a technical resource to the community to help identify problems that should be addressed by each mitigation measure, and financial assistance opportunities through federal, state and private sector programs. (8/31/04)

- For HMGP funds not allocated to projects for the acquisition of substantially damaged structures, the MHMCC and state mitigation staff will review, evaluate, and prioritize proposed mitigation projects and select those projects that will be submitted to FEMA for funding consideration under the HMGP for this disaster. (12/31/04)

- To ensure that the State has appropriate administrative mechanisms in place to implement the HMGP in a timely manner, FEMA will make an initial review of Michigan's existing HMGP State Administrative Plan (approved for 1413-DR-MI) to identify areas that may require an update due to recent changes in federal laws, regulations, rules, policies, and program guidance. FEMA should also consider recent audit findings within the region that may be important to consider during the plan update. (7/30/04)

- State mitigation staff will update the HMGP State Administrative Plan for 1527-DR-MI in accordance with the FEMA plan review. (8/31/04)

NFIP promotion and flood hazard identification

- FEMA Mitigation DAEs and the Michigan Department of Environmental Quality (MDEQ) will review the NFIP participation status of the declared counties in order to determine if additional NFIP promotion opportunities exist. (7/30/04)

  (Note: As the table on the following page indicates, in the 19-county declared area there currently are a total of 283 NFIP participating communities and 15,704 NFIP policies in effect, providing in excess of $2 billion in coverage.)

Flood Insurance Coverage in Affected Counties

COUNTY	Number of NFIP Policies in Effect	Number of NFIP Participating Communities	Approximate Number of Communities in County*	Total NFIP Coverage (in $)
Barry	159	10	21	15,291,900
Berrien	346	27	39	42,847,300
Cass	8	3	20	991,200
Genesee	461	24	32	62,989,700
Gladwin	25	2	17	2,566,800
Ingham	920	14	24	130,577,200
Ionia	101	8	26	8,868,600
Jackson	151	8	27	24,167,900
Kent	659	15	35	96,236,400
Livingston	320	7	20	51,743,200
Macomb	3,690	19	26	485,325,600
Mecosta	38	5	20	3,908,300
Oakland	1,717	41	58	291,410,100
Ottawa	318	19	24	51,444,100
Sanilac	22	8	39	2,847,800
Shiawassee	353	10	27	27,388,900
St. Clair	1,526	18	31	203,377,500
St. Joseph	124	9	24	14,393,700
Wayne	4,766	36	41	491,737,400
TOTALS:	**15,704**	**283**	**551**	**2,008,113,600**

*Note: the number of communities is considered "approximate" because some communities lie in more than one county. Therefore, some were classified in one declared county rather than another (for example, Grosse Pointe Shores was counted in Wayne County but not Macomb), and communities situated in both declared and non-declared counties were included in the declared county totals above.

- Six of the listed affected counties (Berrien, Kent, Macomb, Oakland, Ottawa, and Wayne) are currently undergoing county wide flood insurance map reviews for updating and new map production under Michigan's business plan for the current FEMA Map Modernization initiative. Six other affected counties (Cass, Genesee, Livingston, Sanilac, St. Clair, and St. Joseph) are identified as priority counties for conducting flood insurance reviews, studies and updates. Agency coordination will occur through consultation with the NFIP State coordinator when flood damaged areas are identified and that information should be considered during the current and future county wide studies under the Map Modernization initiative. Additional coordination between FEMA and the state will occur when flood damaged areas are identified and need to be considered during plan development activities under the federal Disaster Mitigation Act of 2000, project development activities under the HMGP, FMAP, and PDMP-C, and disaster rebuilding efforts that comply with minimum state and federal flood damage prevention standards. (10/1/04)

- MDEQ staff will provide technical assistance to local floodplain administrators as needed. (Ongoing)

- MDEQ staff will, as needed, conduct NFIP briefings to inform local floodplain administrators of NFIP responsibilities. (Ongoing)

- FEMA will mail letters to affected communities regarding immediate substantial damage determinations. (Ongoing)

- FEMA will identify (with MDEQ input) priorities for possible enforcement actions regarding floodplain management under the NFIP. (Ongoing)

- MDEQ, EMD/MSP and FEMA will review repetitive flood loss data for potential acquisition, elevation or floodproofing sites. (7/30/04)

- There are four communities located in the 19-county disaster area that have special flood hazard areas identified but either have withdrawn from or are not participating in the NFIP. Those communities are: Village of Stevensville (Berrien County); Township of LaGrange (Cass County) – withdrawn from program; Village of Silver Creek (Cass County) – withdrawn from program; Village of New Lothrop (Shiawassee County). The FEMA Mitigation DAEs and the MDEQ will contact these communities to inquire about their interest in joining the NFIP.

Promoting disaster resistant communities through the PDMP-C, FMAP, CRS and mitigation plan development

- State mitigation staff and the MHMCC will coordinate the use of PDMP-C funds, as appropriate, to promote mitigation plan development and project development in the declared counties to reduce future risk from flooding and severe storms. (12/31/04)

- State mitigation staff and the MHMCC will coordinate the use of FMAP funds, as appropriate, to promote mitigation plan development and project development in the declared counties to reduce future risk from flooding. (12/31/04)

- The MDEQ will coordinate and promote community participation in the NFIP Community Rating System program to reduce future risk from flooding. (Ongoing)

- State mitigation staff and the MHMCC will coordinate and promote the development of local mitigation plans (that are compliant with the federal Disaster Mitigation Act of 2000 and the FMAP) to reduce future risk from flooding and severe storms. (Ongoing)

- State mitigation staff and the MHMCC will coordinate the development of the Michigan Hazard Mitigation Plan (MHMP) and ensure that it is compliant with the federal Disaster Mitigation Act of 2000 to reduce the State's overall risk from flooding, severe storms and other natural hazards. (11/1/04)

- As staff time, resources, and DAE expertise allows, FEMA Mitigation DAEs will support the state and local mitigation planning efforts by collecting / compiling risk assessment data for flooding and severe storm hazards for the 19-county declared area, sufficient to meet the risk assessment planning requirements for state mitigation plans found in Sections 201.4 / c / 2 / ii and iii of the Disaster Mitigation Act of 2000. (8/31/04)

- For the purposes of promoting hazard mitigation in general, FEMA Mitigation DAEs will develop mitigation "success stories" associated with this disaster. The FEMA Mitigation DAEs will work with state mitigation staff to identify communities in the declared area that have implemented mitigation measures in the past which may have prevented damage during this disaster. The DAEs will then interview local officials and/or visit those communities to collect relevant information and write success stories about the mitigation activities. (8/31/04)

Community mitigation education and outreach

- FEMA Mitigation DAEs should consider partnering with the SBA to provide information on the NFIP and appropriate floodproofing techniques for residential and commercial structures. This could be done at the DFO and/or through one-on-one meetings with applicants and community officials. (7/30/04)

- State mitigation staff and the MHMCC will continue to conduct coordination meetings and provide technical assistance on the federal Disaster Mitigation Act of 2000 planning requirements and mitigation plan development with regional and local planning agencies. (Ongoing)

- If a mitigation component is established within the Disaster Field Office (DFO), the EMD/MSP will supply staff, as appropriate and within personnel limitations, to support the DFO mitigation efforts and to monitor disaster-related mitigation activities. (Ongoing)

STATE PRIORITIES FOR FEMA

The State of Michigan recommends the following work priorities for the FEMA Mitigation DAEs assigned to this disaster (listed in order of priority):

Immediate Priorities (to be completed or substantially completed by 7/30/04)

- Review the PDA damaged structure inventory to identify structures that may have been substantially damaged. Mail letters to those affected communities regarding immediate substantial damage determinations.

- Review Michigan's existing HMGP State Administrative Plan (approved for 1413-DR-MI) to identify areas that may require an update due to recent changes in federal laws, regulations, rules, policies, and program guidance. FEMA should also consider recent audit findings within the region that may be important to consider during the plan update.

- Develop mitigation "success stories" associated with this disaster.

High Priorities (to be completed or substantially completed by 8/31/04, after the Immediate Priorities have been addressed)

- Provide guidance to applicants, other community residents, and community officials (through DRCs, the media and other appropriate avenues) that identifies and promotes mitigation measures for individual homes, businesses and community facilities to reduce or eliminate future flood and wind damage. Topics should include:

  - ✓ Appropriate floodproofing solutions for furnaces, water heaters, fuel oil and propane tanks, utilities and other mechanical systems.
  - ✓ Appropriate structural wind engineering and vegetation management solutions to reduce wind damage.

- If possible, collect / compile risk assessment data for flooding and severe storm hazards for the 19-county declared area, sufficient to meet the risk assessment planning requirements for state mitigation plans found in Sections 201.4 / c / 2 / ii and iii of the Disaster Mitigation Act of 2000.

- Upon identification of communities particularly suitable for mitigation, contact local officials to determine the level of local interest in developing a partnership to reduce the community's future risk from flooding and severe storms. Conduct site visits with interested communities to gain commitment in developing projects and implementing appropriate mitigation measures.

- With the assistance of the Michigan Department of Environmental Quality, promote NFIP participation among non-participating communities located within the declared area.

MITIGATION STRATEGY TEAM MEMBERS

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Sandy Glazier, EMD/MSP

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Individual Assistance Officer

Public Assistance Officer

Abigail Eaton, P.E.
MDA / Environmental Stewardship Division

MICHIGAN HAZARD MITIGATION COORDINATING COUNCIL (MHMCC) members:

Captain John Ort, Chair
EMD/MSP

Insp. Kriste Etue, Vice-Chair
EMD/MSP

Ms. Mindy Koch
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Forest, Mineral and Fire Management Division

Vacant (Replacement Pending)
MI Department of Agriculture,
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Mr. Tony Sanfilippo
MI Department of Consumer and Industry Services,
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Ms. Eileen Phifer, PEM
MI Department of Transportation
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Mr. Okey Eneli
MI Department of Management and Budget,
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Livingston County Emergency Management

William Smith, Ottawa County Emergency Manager
Local Emergency Management Representative

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MI Department of Environmental Quality
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FEDERAL EMERGENCY MANAGEMENT AGENCY:

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Deputy Federal Coordinating Officer
For Hazard Mitigation (Chicago)

OTHER FEDERAL AGENCIES:

Sean Duffey
Natural Resource Conservation Service (Lansing, MI)
U.S. Department of Agriculture

Jerry Doline
U.S. Army Corp of Engineers
Detroit District

SIGNED:

(signed on 7/23/04)
SUSAN COSIER, FEMA V
FEDERAL HAZARD MITIGATION OFFICER

(signed on 7/23/04)
MATT SCHNEPP, EMD/MSP
STATE HAZARD MITIGATION OFFICER

ADDENDUM TO THE MICHIGAN HAZARD MITIGATION PLAN FOR FEDERAL DISASTER 1527-DR-MI, DECLARED JUNE 30, 2004

DISASTER HISTORY

Federal Disaster 1527-DR-MI was caused by a series of rain-laden thunderstorms that moved in procession across southern and central Lower Michigan during the period from May 20-24, 2004, which resulted in severe urban and riverine flooding in many areas, but particularly so in southeast Michigan and along the Grand River and its tributaries in central and western Michigan. The severe flooding continued until June 8, when the last remaining flood warning was cancelled by the National Weather Service. The strong storms also caused severe wind damage in several southern Lower Michigan counties. At the height of this disaster, a total of 573,000 American Electrical Power, Consumers Energy, and DTE Energy electrical customers (roughly 6 percent of the State's population) experienced power outages due to wind damage to power lines and other electrical infrastructure. All totaled, nearly 5,000 homes and businesses incurred in excess of $32 million in damage from the flooding and storms. One hundred sixty seven (167) homes and one business incurred major damage. Public damage was also significant in many areas, totaling nearly $7.4 million statewide. However, in the counties of Arenac, Berrien, Barry, Cass, Gladwin, St. Clair and St. Joseph, public damage losses were particularly high.

In response to the storms, Governor Jennifer Granholm ordered the State Emergency Operations Center (SEOC) partially activated on May 21, 2004 to monitor the situation and collect / compile damage and impact assessment information. On May 25, Governor Granholm and Lt. Governor Cherry toured affected areas in Ionia County and Macomb County to review the damage firsthand. On June 3, Governor Granholm declared a State of Disaster, pursuant to 390 PA 1976, as amended, for the following 23 affected Michigan counties: Arenac; Barry; Berrien; Cass; Genesee; Gladwin; Ingham; Ionia; Jackson; Kent; Livingston; Macomb; Mecosta; Newaygo; Oakland; Ottawa; Saginaw; St. Clair; St. Joseph; Sanilac; Shiawassee; Van Buren; and Wayne. State agencies were directed to provide whatever assistance they could to assist the 23 affected counties in responding to and recovering from the flooding and storm damage.

On May 28, 2004 Governor Granholm and the Emergency Management Division of the Michigan State Police (EMD/MSP) requested the Federal Emergency Management Agency (FEMA) and U.S. Small Business Administration (SBA) to conduct a joint federal / state / local Preliminary Damage Assessment (PDA) of the damaged areas in order to document the nature, scope, magnitude and recovery costs of the disaster. The PDA was conducted on June 2-5 by a total of eight survey teams – four examining damage to individuals and businesses, and four examining damage to public facilities and infrastructure.

The PDA individual assistance teams determined that the most severe impacts to individuals and businesses occurred in the counties of Barry, Berrien, Jackson, Kent, Livingston, Macomb, Oakland, St. Clair and Wayne, which collectively had nearly 94 percent of the major damage and 96 percent of the minor damage to structures. The PDA teams estimated that 163 homeowners will require rental assistance for up to two months at a total cost of nearly $235,000. Repair assistance for 2,539 homeowners is estimated to cost in excess of $6.5 million, while home replacement costs for five homeowners are estimated at an additional $51,000. All totaled, the teams identified 2,637 homeowners that will require federal housing assistance in the aftermath of this disaster, at a total cost of $6.8 million. The teams also identified over $1.6 million in "Other Needs Assistance (ONA)" for 644 homeowners, which will cover the replacement of essential household items that were damaged or destroyed by the flooding and storms. The combined housing assistance needs and ONA exceed $8.4 million, which equates to more than $3,000 per affected homeowner. The remainder of the $32 million in home and business damage will likely be covered by SBA low-interest disaster loans.

The damage to public facilities was equally widespread and severe. The PDA teams identified nearly $7.4 million in public damage costs, the majority of which ($4.7 million) was for Category A (debris removal) and Category C (roads and bridges) work under the federal Public Assistance Grant Program. The teams also identified $916,255 in Category B work (emergency protective measures), while Category D, E, F and G damages totaled another $1,743,200. One-third of the public damage occurred in the counties of St. Clair, Cass and Berrien, although damage was fairly uniformly spread throughout the affected area. All but three of the affected counties had public damage in excess of $100,000, and most had damage in excess of $250,000.

On June 18, 2004 Governor Granholm submitted her letter of request to the President for federal disaster relief assistance for the affected counties. On June 30, 2004, President Bush granted that request and declared a Major Disaster for the counties of Barry, Berrien, Cass, Genesee, Gladwin, Ingham, Ionia, Jackson, Kent, Livingston, Macomb, Mecosta, Oakland, Ottawa, Sanilac, Shiawassee, St. Clair, St. Joseph and Wayne. (The counties of Arenac, Newaygo, Saginaw and Van Buren, which were included in Governor Granholm's initial request, were not included in the President's Declaration.) On July 22, 2004, a request by the state for an additional four counties to be included in the declaration was granted, making Eaton, Muskegon, Saginaw and Washtenaw counties all eligible for federal disaster relief assistance.

The President's Declaration makes available Individual Assistance and Hazard Mitigation Assistance, but not Public Assistance. (The Individual Assistance will be limited to the 23 declared counties, while the Hazard Mitigation Assistance

will be available on a statewide basis in accordance with existing federal and state policy.) On June 30, 2004, the Small Business Administration also issued a Disaster Declaration for the counties of Barry, Berrien, Cass, Eaton, Genesee, Gladwin, Ingham, Ionia, Jackson, Kent, Livingston, Macomb, Mecosta, Muskegon, Oakland, Ottawa, Saginaw, Sanilac, Shiawassee, St. Clair, St. Joseph, Washtenaw, and Wayne, which makes low-interest disaster loans available to affected residents in those nineteen counties as well as the contiguous counties of Allegan, Arenac, Bay, Branch, Calhoun, Clare, Clinton, Eaton, Gratiot, Hillsdale, Huron, Isabella, Kalamazoo, Lake, Lapeer, Lenawee, Midland, Monroe, Montcalm, Muskegon, Newaygo, Ogemaw, Osceola, Roscommon, Saginaw, Tuscola, Van Buren, and Washtenaw.

AREA AFFECTED

The Presidential Major Disaster Declaration includes the following 23 Michigan counties: Barry, Berrien, Cass, Eaton, Genesee, Gladwin, Ingham, Ionia, Jackson, Kent, Livingston, Macomb, Mecosta, Muskegon, Oakland, Ottawa, Saginaw, Sanilac, Shiawassee, St. Clair, St. Joseph, Washtenaw, and Wayne. As indicated in the "Disaster History" section above, the PDA findings indicate that the most serious damage to homes / businesses occurred in the counties of Barry, Berrien, Jackson, Kent, Livingston, Macomb, Oakland, St. Clair and Wayne. The counties of Wayne and Macomb were particularly hard hit, with 73 and 39 homes, respectively, with major damage. Those two counties combined also had a total of 2,948 homes with minor damage. The counties of Barry and St. Clair also had high numbers of homes with major damage (27 and 28, respectively). In Berrien County, 11 homes and six businesses had major damage.

Map of Declared Area

MITIGATION STRATEGY

The Federal Emergency Management Agency (FEMA) and the Emergency Management Division of the Michigan State Police (EMD/MSP) jointly developed a Mitigation Strategy for this Major Disaster Declaration that addresses the mitigation problems and opportunities unique to this event. (See attached Strategy.)

HMGP PROCEDURES

The Hazard Mitigation Grant Program (HMGP) has been activated for Federal Disaster 1527-DR-MI. The procedures outlined in the State of Michigan Administrative Plan for the Hazard Mitigation Grant Program will be followed in the implementation and administration of the program. In accordance with the HMGP State Administrative Plan provisions and Michigan Executive Order 1998-5, the EMD/MSP and the Michigan Hazard Mitigation Coordinating Council (MHMCC) will jointly carry out the HMGP project identification, prioritization, and selection processes.

Hazard Mitigation Strategy for Federal Disaster #1413: 2002 Central and Western Upper Peninsula Flooding

ADDENDUM TO THE MICHIGAN HAZARD MITIGATION PLAN FOR FEDERAL DISASTER 1413-DR-MI, DECLARED MAY 6, 2002

DISASTER HISTORY

Federal Disaster 1413-DR-MI was caused by the combined forces of unseasonably warm temperatures, rainfall, ice jams and an all-time record snowpack in the central and western Upper Peninsula. These forces collided on the weekend of April 13-14, 2002, causing rivers and streams throughout the area to swell out of their banks, flooding many areas in the five-county region over the course of the following week. All-time flood levels were recorded on several rivers and streams in the area. Gogebic County was particularly hard hit, especially in and around Ironwood, Wakefield, and Marenisco. The counties of Baraga, Houghton, Marquette and Ontonagon also sustained heavy damage to roads, bridges and other public facilities.

In response to the flooding, Governor John Engler declared a State of Disaster for Gogebic County on April 16, 2002 and activated the Michigan National Guard and numerous other state agencies to assist Gogebic County and other affected areas in responding to and recovering from the disaster. The Governor's State of Disaster Declaration was amended on April 30, 2002 to include the counties of Baraga, Houghton, Marquette and Ontonagon.

A joint federal/state/local Preliminary Damage Assessment (PDA) was conducted on April 22-24. That PDA indicated that the most severe impacts were to the cities of Ironwood and Wakefield in Gogebic County, and to the counties of Baraga and Marquette, although considerable flood damages were experienced in all five declared counties. The PDA teams identified 170 homes and businesses that incurred flood damage in the cities of Ironwood and Wakefield – 25 of which incurred major damage and likely will be eligible for SBA Disaster Loans. All totaled, the PDA teams identified over $1.2 million in damages and impacts to individuals and homes/businesses, most of which occurred in the cities of Ironwood and Wakefield.

The PDA teams identified nearly $11 million in damages and impacts to roads, bridges, culverts and other public facilities and services in the five-county impact area. Gogebic County incurred nearly $7.8 million in public damage, the vast majority of which ($6.7 million) was to roads and bridges. Marquette County had $928,000 in public damage, of which $739,000 was to roads and bridges. All of Baraga County's $569,250 in public damage was to roads and bridges. Houghton County had over $200,000 in road and bridge damage, and Ontonagon County had nearly $70,000. These individual county figures do not include the damages to Federal-Aid roads and bridges, which totaled $1 million for the five-county area.

On April 30, 2002, Governor John Engler submitted his letter of request to the President for federal disaster relief assistance for the affected counties. On May 6, 2002, President Bush granted that request and declared a Major Disaster for the counties of Baraga, Gogebic, Houghton, Marquette and Ontonagon. The President's Declaration made available Public Assistance and Hazard Mitigation Assistance, but not Individual Assistance. On May 8, Governor John Engler formally requested that the Small Business Administration (SBA) issue a Disaster Declaration for Gogebic County and activate its Disaster Loan Program for the residents of the county that incurred major flood damage. That declaration was granted by the SBA on May 10. The SBA Declaration for Gogebic County also makes low interest disaster loans available to affected residents in the contiguous counties of Iron and Ontonagon.

On May 10, 2002, Governor John Engler approved the addition of Iron County to his earlier State of Disaster Declarations issued on April 16 and April 30. On May 24, 2002, Iron County and the Keweenaw Bay Indian Community were added to the Presidential Major Disaster Declaration for Public Assistance at the request of the State of Michigan, and upon concurrence of FEMA.

AREA AFFECTED

The Presidential Major Disaster Declaration includes the counties of Baraga, Gogebic, Houghton, Iron, Marquette and Ontonagon, and the Keweenaw Bay Indian Community. The most serious impacts to individuals and homes/businesses occurred in the cities of Ironwood and Wakefield in Gogebic County. The most heavily impacted areas for public damages were the counties of Gogebic, Marquette and Baraga. In Gogebic County, the majority of the public damages occurred in or around the cities of Ironwood, Wakefield and Marenisco.

MITIGATION STRATEGY

The Federal Emergency Management Agency (FEMA) and the Emergency Management Division of the Michigan State Police (EMD/MSP) jointly developed a Mitigation Strategy for this Major Disaster Declaration that addresses the mitigation problems and opportunities unique to this event. (See attached Strategy.)

HMGP PROCEDURES

The Hazard Mitigation Grant Program (HMGP) has been activated for Federal Disaster 1413. The procedures outlined in the State of Michigan Administrative Plan for the Hazard Mitigation Grant Program will be followed in the implementation and administration of the program. In accordance with the HMGP State Administrative Plan provisions and Michigan Executive Order 1998-5, the EMD/MSP and the Michigan Hazard Mitigation Coordinating Council (MHMCC) will jointly carry out the HMGP project identification, prioritization, and selection processes.

Michigan has been a "Managing State" for the HMGP since October 2000. The FEMA and EMD/MSP have signed a joint Memorandum of Understanding outlining each party's responsibilities in implementing and administering the HMGP in Michigan subsequent to a federally-declared disaster. The provisions of that MOU were incorporated into the State Administrative Plan for the HMGP and will be followed for Federal Disaster 1413.

MITIGATION STRATEGY - FEMA-1413-DR-MI
State of Michigan

OBJECTIVE

The objective of mitigation is to reduce future disaster losses through acquisition and relocation of hazard-prone property, structural retrofitting, mitigation education of community officials and residents, wise land use and land development practices, prudent use of resources and funding, and encouragement of National Flood Insurance Program (NFIP) implementation and compliance, to name just a few measures that have been successful. To assist communities in Michigan with mitigation efforts, so that the environment is safer and has a reduced risk from disaster damage, the following objectives must be accomplished:

4. Mitigation opportunities will be identified and selected:

   - The initial mitigation opportunities and recommendations identified during the damage assessment process in many of the affected communities include the following:

     A. Acquisition and relocation or retrofitting and flood proofing (including elevation) of substantially damaged structures located in flood prone areas.
     B. Community outreach and education to promote flood proofing methods in residential and commercial structures, focusing on elevation and/or relocation of utilities and mechanical systems in basements or other vulnerable areas.
     E. Applying the best methods to properly anchor and/or elevate or floodproof fuel oil tanks in home basements.
     F. Floodproofing roads, bridges, culverts and other public facilities located in floodplains or other floodprone areas.
     G. Armoring erosion prone streambanks to prevent sedimentation and to otherwise ensure maximum hydraulic capacity is maintained.
     H. Assessing the need for initial or revised flood hazard mapping in selected communities.

5. Financial resources, including disaster assistance programs such as the HMGP and PAGP, and the funds from other state and federal programs, will be maximized:

   - Under the Public Assistance Grant Program, inspectors will make <u>every effort</u> to include appropriate mitigation measures in restoring damaged public facilities (<u>on every project</u>) – including the removal of disaster-caused debris from culverts and streambeds to ensure maximum hydraulic capacity.

   - Under the Federal Highway Administration (FHWA) Emergency Relief Program, inspectors will make every effort to include appropriate mitigation measures in restoring damaged Federal-Aid roads and bridges.

   - Under the Small Business Administration, low interest loans can be acquired for repairs and mitigation upgrades to damaged structures.

- Under the Natural Resource Conservation Service (NRCS) Emergency Watershed Program, appropriate mitigation measures will be implemented to remove any and all threats (urgent and compelling) resulting from sudden watershed impairment. In addition, supplemental funding will be requested to implement appropriate mitigation measures at other damaged, impacted or threatened sites (not considered urgent and compelling) that do not fall under the purview of the FEMA Public Assistance Grant Program or other programs.

- The maximum seven-percent (7%) allotment of available HMGP funds will be earmarked by the State to facilitate the development of local hazard mitigation plans in the declared disaster area and in other communities in the region.

- Under the HMGP, funds will be earmarked to acquire/relocate substantially damaged structures located in flood prone areas. In addition, FEMA will be requested to make available PAGP funds to cover the demolition and debris removal costs associated with these acquisitions.

- Under the Pre-Disaster Mitigation Program (PDMP), funds will be made available as appropriate (at the discretion of the State) to support mitigation planning efforts in the declared area.

- Voluntary organizations (i.e., Red Cross, Salvation Army, etc.) will be requested to provide (as appropriate and in keeping with their organizational mission) financial and other resources to promote and facilitate the implementation of mitigation measures in individual damaged homes.

6. Long-term mitigation will be ensured through comprehensive and prudent public health and safety measures (i.e., floodproofing utilities, mechanical systems, and basement fuel oil tanks in residences and businesses), local building practices, and floodplain management.

STRATEGY

The mitigation strategy for promoting and achieving hazard mitigation in this disaster will be focused on the following areas:

- Public health and safety measures.
- Community mitigation education and outreach.
- Coordination with the FEMA PAGP, the FHWA Emergency Relief Program, and the NRCS Emergency Watershed Program.
- Community administered floodproofing measures.
- Mitigation project development.
- National Flood Insurance Program promotion and flood hazard identification.
- Promoting disaster resistant communities through the Pre-Disaster Mitigation Program and through local mitigation plan development.

Public health and safety measures

- Assist community officials and residents in identifying appropriate floodproofing solutions for basement fuel oil tanks, utilities and other mechanical systems that will ensure public health and safety. The Michigan Hazard Mitigation Coordinating Council has a representative from the Michigan Department of Environmental Quality (MDEQ). Public health and safety issues pertaining to the flood damages in individual homes and businesses related to this disaster can be discussed at an upcoming MHMCC meeting and suggestions taken from the MDEQ representative. In addition, FEMA Disaster Assistance Employees (DAEs) can provide written guidance materials directly to individual homeowners through community outreach at a Disaster Recovery Center (DRC), through the media, or through other appropriate avenues. (6/19/02)

Community mitigation education and outreach

- Coordinate with public and private agencies in the development of flood resistant building practices and a multi-hazard mitigation plan for each declared county. (12/27/02 – to initiate plan development discussions)

- FEMA should consider partnering with the SBA to provide information on the National Flood Insurance Program (NFIP) and floodproofing techniques for residential and commercial structures. This could be done at the SBA's Loan Assistance Office at the DFO and/or through one-on-one meetings with applicants and community officials. (5/31/02)

- Conduct workshops on the DMA 2000 planning requirements and mitigation plan development with regional and local planning agencies. (5/31/02)

Coordination with the Public Assistance Grant Program and other active relief programs

- Provide guidance to PAGP applicants that promotes mitigation and specifies the types of measures that are potentially eligible for funding under the PAGP. (5/17/02)

- Coordinate with FEMA PAGP inspectors to ensure that appropriate mitigation measures are allowed and specified for damaged roads, bridges, culverts and other public facilities – including the removal of disaster-caused debris from culverts and streambeds to ensure maximum hydraulic capacity. This is best achieved by having FEMA Mitigation DAEs (preferably) and/or state mitigation staff (as a backup) be part of the PAGP inspection teams sent out to survey damaged sites. In addition, FEMA Mitigation DAEs (preferably) and/or state mitigation and PAGP staff should review each damage report written by the PAGP inspectors to ensure that mitigation measures have been considered on every project. The FEMA Deputy Coordinating Officer (FCO) for Mitigation should also review the PAGP inspection report trends (i.e., the percent of all PAGP projects that have specified mitigation measures) to ensure that mitigation measures are being specified in all appropriate circumstances and for all appropriate types of projects. (5/31/02)

- Coordinate with FHWA inspectors to ensure that appropriate mitigation measures are being considered for damaged Federal-Aid roads and bridges being repaired under the FHWA Emergency Relief Program. This is best achieved by having the Michigan Department of Transportation (MDOT) representative in (or reporting to) the DFO to monitor and evaluate the decisions being made by FHWA inspectors in the field. If mitigation measures are not being considered, the FEMA Deputy FCO for Mitigation should contact the FHWA and request that mitigation be considered where appropriate and cost-effective. (5/31/02)

- Coordinate with NRCS inspectors to ensure that appropriate mitigation measures are being considered on all sites being restored under the NRCS Emergency Watershed Program and other activated programs. This is best achieved by having state mitigation staff monitor and evaluate the decisions being made by NRCS inspectors in the field and central office program staff in Lansing. If mitigation measures are not being considered, the FEMA Deputy FCO for Hazard Mitigation should contact the NRCS and request that mitigation be considered where appropriate and cost-effective. (5/31/02)

- Coordinate with the U.S. Army Corp of Engineers (USACE) on the possible development of flood control projects within or benefiting the declared area. (5/31/02)

Community-administered floodproofing measures

- Invite communities to establish and administer a locally based floodproofing program that would provide public education on proper floodproofing techniques, and provide grants to individual home and business owners wishing to retrofit their structures to reduce flood damage. The program could be implemented and administered by an existing local department, such as the building, planning or public works department, who would be responsible for disbursing grants, monitoring work, providing technical assistance, and providing program status to the State. (8/30/02)

  Note: floodproofing methods could include the following:
  - Acquire and demolish/relocate floodprone structures.
  - Elevate floodprone structures above the base flood level (100-year flood).
  - Securely mount basement fuel oil tanks to prevent tank ruptures during flooding.
  - Installation of standpipes, sewer backflow (check) valves, or revised plumbing to include an ejector or sump pump for basements.
  - Raise electrical system components including service panels, meters, switches, and outlets that may easily be damaged by floodwater.
  - Raise or relocate HVAC equipment, water heater, and washer/dryer.

Mitigation project development

- Information from the Preliminary Damage Assessment (PDA) will be used to help identify the communities that should be contacted concerning the possibility of mitigation opportunities under the Hazard Mitigation Grant Program (HMGP) and other state and federal programs. (8/30/02)

- Review the potentially damaged structure inventory from the PDA, concentrating primarily on structures that may have been substantially damaged. (5/31/02)

- Review the NFIP State Coordinator's information concerning the flood hazard identification and participation status of communities in the NFIP. (5/31/02) (Note: The NFIP State Coordinator has already provided this information to the EMD/MSP. As the table below indicates, in the five-county declared area there are a total of 12 NFIP participating communities and 105 NFIP policies in effect, totaling $9.7 million in coverage.)

Flood Insurance Coverage in Affected Counties

COUNTY	Number of NFIP Policies in Effect	Number of NFIP Participating Communities	Total NFIP Coverage
Gogebic	12	3	$ 994,700
Ontonagon	23	3	$1,473,300
Baraga	20	2	$1,785,700
Houghton	1	1	$ 31,600
Marquette	49	3	$5,448,600
TOTALS:	**105**	**12**	**$9,733,900**

- Coordinate with the Michigan Economic Development Corporation, Michigan Department of Career Development, Michigan State Housing Development Authority, and other appropriate state agencies concerning communities with a substantial investment of state financial resources. (11/01/02)

- Whenever possible, incorporate mitigation projects into larger, ongoing or planned community projects (as long as the larger project will be completed in a timely manner and mitigation benefits can be fully retained). (Ongoing)

- Upon identification of communities suitable for mitigation, local officials will be contacted to determine the level of local interest in partnering towards recovery that will reduce the community's risk to future flooding. The Mitigation Team will be activated and conduct site visits with communities, as necessary, to gain commitment in developing projects and implementing appropriate mitigation measures. The Mitigation Team will function as a technical resource to the community to help identify problems that should be addressed by the mitigation measure and identify financial assistance opportunities through federal, state and private sector programs.

- If a mitigation component is established within the Disaster Field Office (DFO), the EMD/MSP will supply staff, as appropriate, to support the DFO mitigation efforts.

- The mitigation team will evaluate the mitigation projects proposed within Michigan and select those projects that will be funded under the Hazard Mitigation Grant Program. (8/30/02)

NFIP promotion and flood hazard identification

- FEMA will collect and assess flood map upgrade needs data using the NFIP's Map Needs Update Support System database. Where no NFIP maps are available, the map needs data collection process shall include a community-wide assessment of flood damage potential according to NFIP standards. FEMA shall coordinate with the United States Geological Survey (USGS), the MDEQ, and the NFIP Regional Engineer to determine the need for collection of high water data. In addition, FEMA shall coordinate with PAGP inspection staff to determine where floodplain map data would enhance benefit-cost analysis for potential mitigation-induced project enhancements and prepare hydrologic and hydraulic analyses as required. Working in consultation with the NFIP State Coordinator, FEMA will identify areas where flood damage has occurred to residential or commercial building stock and prepare flood recovery maps as required to assist in rebuilding efforts that comply with minimum state and federal flood damage prevention standards. (12/27/02)

- MDEQ staff will provide technical assistance to local floodplain administrators as needed. (Ongoing)

- MDEQ staff will, as needed, conduct NFIP briefings to inform local floodplain administrators of NFIP responsibilities. (Ongoing)

- FEMA will mail letters to affected communities regarding immediate substantial damage determinations. (Ongoing)

- FEMA will identify (with MDEQ input) priorities for possible enforcement actions. (Ongoing)

- MDEQ, EMD/MSP and FEMA will review repetitive loss data for potential acquisition, elevation or floodproofing sites. (6/14/02)

- There is one NFIP sanctioned community (L'Anse Township) in the five-county disaster area. This community has applied to join the NFIP and should be eligible shortly.

Promoting disaster resistant communities through the Pre-Disaster Mitigation Program and through local mitigation plan development

- Coordinate the use of PDMP funds, as appropriate, to promote mitigation plan development to ensure less disaster damage in the future. (12/00)

MITIGATION STRATEGY TEAM MEMBERS

STATE OF MICHIGAN:

Doran Duckworth, EMD/MSP
Mitigation staff Supervisor

Matt Schnepp, EMD/MSP
Assistant State Hazard Mitigation Officer

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National Flood Insurance Program Coordinator

Eileen Phifer, PEM
MDOT Maintenance Division
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Sandy Glazier, EMD/MSP
Public Assistance Officer

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Local Hazard Mitigation Planner

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Bruce Menerey, P.E.
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Floodplain Management Specialist

Angela Houseman, EMD/MSP
Administrative Assistant

Dawn Schulert, EMD/MSP
State Hazard Mitigation Officer
(available after July 8, 2002)

Bethany Hall, EMD/MSP
Manager, Mitigation and Recovery Section

MICHIGAN HAZARD MITIGATION COORDINATING COUNCIL (MHMCC) members:

Captain John Ort, Chair
MI Department of State Police,
Emergency Management Division

Mr. Edward Hagan
MI Department of Natural Resources,
Forest Management Division

Mr. Tony Sanfilippo
MI Department of Consumer and Industry Services,
Office of Fire Safety

Mr. Okey Eneli
MI Department of Management and Budget,
Office of Design and Construction

Dr. William D. Wagoner
Livingston County Emergency Management

Mr. George Hosek
MI Department of Environmental Quality,
Land and Water Management Division

Mr. Robert Tarrant (Appointment Pending)
MI Department of Agriculture,
Marketing and Communications Division

Ms. Eileen Phifer, PEM
MI Department of Transportation
Maintenance Division

Kevin Thomason
Property and Casualty Insurance Representative
State Farm Insurance Company

William Smith, Ottawa County Emergency Manager
Local Emergency Management Representative

FEDERAL EMERGENCY MANAGEMENT AGENCY:

Andrew Vlack
Federal Hazard Mitigation Officer (DFO)

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Federal Hazard Mitigation Officer (Chicago)

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Jerry Doline
U.S. Army Corp of Engineers
Detroit District

SIGNED:

(signed)
NORBERT SCHWARTZ, FEMA V
DEPUTY FCO FOR MITIGATION

(signed)
DORAN DUCKWORTH, EMD/MSP
ACTING STATE HAZARD MITIGATION OFFICER

DATE

DATE

Hazard Mitigation Strategy for Federal Disaster #1346: 2000 Detroit Area Urban Flooding

ADDENDUM TO THE MICHIGAN HAZARD MITIGATION PLAN FOR FEDERAL DISASTER 1346, DECLARED OCTOBER 17, 2000

DISASTER HISTORY

Federal Disaster 1346 was caused by unusually heavy rainfall that occurred in Wayne County on September 10 and 11, 2000. The rain-laden thunderstorms that moved across the southern tier of counties in Michigan on those two days hit Wayne County particularly hard. The National Weather Service indicated that up to four inches of rain fell in parts of Wayne County on Sunday, September 10. An additional two to four inches of rain fell over the same areas on Monday, September 11. Detroit Metropolitan Airport recorded 3.71 inches of rain on September 11, eclipsing the previous record for the day of 1.72 inches set back in 1947. The 3.71 inches of rain also broke the one-day rainfall total for any day in September in Wayne County (3.21 inches) set on September 3, 1879, and was the fifth wettest day ever in the Detroit area.

The cumulative effect of the two storms overwhelmed many storm sewers and sewage treatment plants, causing raw sewage to back up into homes and businesses and sending untreated waste into rivers and streams. The storms left nearly 35,000 utility customers without power and stranded more than 17,000 air passengers at Detroit Metropolitan Airport. Numerous roads, bridges, and highway underpasses were flooded and had to be closed, which limited the ability of emergency service vehicles to reach many areas in a timely manner.

According to figures compiled by the affected local communities and Preliminary Damage Assessment (PDA) teams coordinated by the Federal Emergency Management Agency, the excessive rainfall caused flooding in 3,211 private residences and businesses. Some of the flooding was caused by water moving over land from swollen streams, creeks, and retention ponds. However, the vast majority of the damage was due to sewer backups into homes and businesses caused by power failures at pumping stations and/or the capacity of the storm water collection system being overwhelmed. Sewage depths in basements ranged from several inches up to several feet or more. In some cases, the water depths entered the first floor of the structure, causing major damage to living quarters.

Thousands of homes had primary mechanical systems such as the furnace, water heater, and electrical service damaged from floodwater infiltration. Many of these systems will require major repairs or have to be replaced. In addition, many homeowners incurred damage to clothes washers and dryers, freezers, power machinery, and other appliances commonly found in basement utility spaces. A large number of homes had finished living spaces in their basements. The flooding, in many cases, destroyed the furnishings, carpeting, wall paneling, and personal items in those living spaces. Several business owners incurred significant losses in appliances, cabinetry, carpeting, and inventory items that were stored in basements and ground floor storage spaces.

AREA AFFECTED

The primary areas affected by this disaster are the Wayne County communities of Allen Park, Dearborn, Dearborn Heights, Ecorse, Lincoln Park, Riverview, Southgate, Taylor, Van Buren Township, Wyandotte, and the city of Wayne. The city of Southgate was particularly hard hit, suffering damage to 3,340 homes and businesses alone. Allen Park had flooding damage to 2,500 homes and businesses. In Wyandotte, more than 1,300 structures flooded. Dearborn, Dearborn Heights, Ecorse, Lincoln Park, and Taylor each had several hundred homes and businesses flooded.

MITIGATION STRATEGY

The Federal Emergency Management Agency (FEMA) and the Emergency Management Division of the Michigan State Police (EMD/MSP) jointly developed a Mitigation Strategy for this Major Disaster Declaration that addresses the mitigation problems and opportunities unique to this event. (See attached Strategy.)

HMGP PROCEDURES

The Hazard Mitigation Grant Program (HMGP) has been activated for Federal Disaster 1346. The procedures outlined in the State of Michigan Administrative Plan for the Hazard Mitigation Grant Program will be followed in the implementation and administration of the program. In accordance with the HMGP State Administrative Plan provisions and Michigan Executive Order 1998-5, the EMD/MSP and the Michigan Hazard Mitigation Coordinating Council (MHMCC) will jointly carry out the HMGP project identification, prioritization, and selection processes.

Michigan was recently designated as a "Managing State" for the HMGP. The FEMA and EMD/MSP have jointly developed a draft Memorandum of Understanding outlining each party's responsibilities in implementing and administering the HMGP in Michigan subsequent to a federally-declared disaster. The provisions of that MOU will be incorporated into the State Administrative Plan for the HMGP and will be followed for Federal Disaster 1346.

MITIGATION STRATEGY
FEMA-1346-DR-MI
State of Michigan

OBJECTIVE

The objective of mitigation is to reduce future disaster losses through acquisition and relocation of hazard-prone property, structural retrofitting, mitigation education of community officials and residents, wise land use and land development practices, prudent use of resources and funding, and encouragement of National Flood Insurance Program (NFIP) implementation and compliance, to name just a few measures that have been successful. To assist communities in Michigan with mitigative efforts, so that the environment is safer and has a reduced risk from disaster damage, the following objectives must be accomplished:

7. Mitigation opportunities will be identified and selected:

   - The initial mitigation opportunities and recommendations identified during the damage assessment process in many of the affected communities include the following:

     A. Apply the best methods to reduce or eliminate sewer backup incidents.
     B. Community outreach and education to promote flood proofing methods.
     C. Acquisition and relocation or retrofitting and flood proofing (including elevation) of substantially damaged structures located in flood prone areas.

8. Financial resources, including disaster assistance programs such as the HMGP, PAGP and IFGP, and the funds from other state and federal programs, will be maximized:

   - Under the Individual and Family Grant Program and Temporary Housing Minimal Repair Program, inspectors will make every effort to include mitigation measures in restoring damaged properties.

   - Under the Small Business Administration, low interest loans can be acquired for repairs and mitigation upgrades to damaged structures.

9. Long-term mitigation will be ensured through comprehensive and prudent life saving measures (i.e., restoring and floodproofing basement utilities and mechanical systems, preventing sewer backups), local building practices, and floodplain management.

STRATEGY

The mitigation strategy for promoting and achieving hazard mitigation in this disaster will be focused on the following areas:

- Life safety measures.
- Community mitigation education and outreach.
- Coordination with the Individual and Family Grant Program and the Temporary Housing Minimal Repair Program.
- Community-administered flood proofing measures.
- Mitigation project development.
- National Flood Insurance Program mitigation opportunities and promotion.
- Promoting disaster resistant communities through Project Impact.

Life safety measures

- Assist community officials in identifying deficiencies in storm sewer design and develop solutions that will ensure public health and safety. The Michigan Hazard Mitigation Coordinating Council has a representative from the Michigan Department of Environmental Quality (MDEQ). Issues pertaining to this disaster will be discussed by the MHMCC and suggestions taken from the MDEQ representative. (11/17/00)

Community mitigation education and outreach

- Coordinate with public and private agencies in the development of flood resistant building practices. (11/17/00)
- Two Disaster Recovery Centers (DRCs) have been opened for this disaster – one in Taylor and one in Dearborn. The DRCs are staffed by FEMA-trained Disaster Assistance Employees (DAEs) knowledgeable of the NFIP and mitigation of sewer backups. (Note: The DRCs are scheduled to close 11/3/00.)

Coordination with the Individual and Family Grant Program

- Coordinate with the Individual and Family Grant Program and the Temporary Housing Minimal Repair Program staff to ensure that appropriate flood proofing measures are allowed and specified for homes, businesses, and infrastructure being restored under these two programs. (12/00)

Community-administered floodproofing measures

- Invite communities to establish and administer a locally-based floodproofing program that would provide public education on proper floodproofing techniques, and provide grants to individual home and business owners wishing to retrofit their structures to reduce flood damage. The program could be implemented and administered by an existing local department, such as the building, planning or public works department, which would be responsible for disbursing grants, monitoring work, providing technical assistance, and providing program status to the State. (12/00)

- Flood proofing methods could include the following:
  - Installation of standpipes, sewer backflow (check) valves, or revised plumbing to include an ejector or sump pump for basements.
  - Raise electrical system components including service panels, meters, switches, and outlets that may easily be damaged by floodwaters.
  - Raise or relocate HVAC equipment, water heater, and washer/dryer.

Mitigation project development

- Information from the Preliminary Damage Assessment (PDA) will be used to help identify the communities that should be contacted concerning the possibility of mitigation opportunities under the Hazard Mitigation Grant Program (HMGP) and other state and federal programs. (12/00)
- Review the potentially damaged structure inventory from the PDA, concentrating primarily on structures that may have been substantially damaged. (12/00)
- Review the NFIP State Coordinator's information concerning the flood hazard identification and participation status of communities in the NFIP. (12/00) (Note: The NFIP State Coordinator has indicated that the Village of Lake Angelus in Oakland County is the only NFIP sanctioned community in the two-county disaster area.)
- Coordinate with the Michigan Economic Development Corporation, Michigan Department of Career Development, Michigan State Housing Development Authority, and other appropriate state agencies concerning communities with a substantial investment of state financial resources. (12/00)
- Whenever possible, incorporate mitigation projects into larger, ongoing or planned community projects (as long as the larger project will be completed in a timely manner and mitigation benefits can be fully retained). (Ongoing)
- Upon identification of communities suitable for mitigation, local officials will be contacted to determine the level of local interest in partnering towards recovery that will reduce the community's risk to future severe storms and flooding. The Mitigation Team will be activated and conduct site visits with communities, as necessary, to gain commitment in developing projects and implementing appropriate mitigation measures. The Mitigation Team will function as a technical resource to the community to help identify problems that should be addressed by the mitigation measure and identify financial assistance opportunities through federal, state and private sector programs.
- If a mitigation component is established within the Disaster Field Office (DFO), the EMD/MSP will supply staff, as appropriate, to support the DFO mitigation efforts.
- The Mitigation Team will evaluate the mitigation projects proposed within Michigan and select those projects that will be funded under the Hazard Mitigation Grant Program. (3/01)

NFIP mitigation opportunities and promotion

- MDEQ staff will provide technical assistance to local floodplain administrators as needed. (Ongoing)
- MDEQ staff will, as needed, conduct NFIP briefings to inform local floodplain administrators of NFIP responsibilities. (Ongoing)
- FEMA has ordered three sets of NFIP maps for the declared area.
- FEMA will mail letters to affected communities regarding immediate substantial damage determinations. (Ongoing)
- FEMA will identify priorities for possible enforcement actions. (Ongoing)
- MDEQ, EMD/MSP, and FEMA will review repetitive loss data for potential acquisition, elevation or flood proofing sites. (12/00)
- The NFIP State Coordinator has indicated that the Village of Lake Angelus in Oakland County is the only NFIP sanctioned community in the two-county disaster area.

Promoting disaster resistant communities through Project Impact

- Coordinate with Michigan Project Impact communities in promoting mitigation projects to ensure less disaster damage in the future. (12/00)

MITIGATION STRATEGY TEAM MEMBERS

STATE OF MICHIGAN:

Doran Duckworth
Hazard Mitigation Coordinator

Dawn Schulert
Hazard Mitigation Officer

Matt Schnepp
Assistant Grants Manager

Karen Totzke
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National Flood Insurance Program Coordinator

Angela Houseman
Mitigation Administrative Assistant

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Mr. George Hosek
MI Department of Environmental Quality,
Land and Water Management Division

Mr. Edward Hagan
MI Department of Natural Resources,
Forest Management Division

Mr. P. David Charney
MI Department of Agriculture,
Marketing and Communications Division

Mr. Craig Newell
MI Department of Consumer and Industry Services,
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Ms. Eileen Phifer
MI Department of Transportation
Maintenance Division

Mr. Duane Berger
MI Department of Management and Budget,
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Mr. Kurt Gallinger
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Dr. William D. Wagoner
Livingston County Emergency Management

Mr. Rodney Krieger
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FEDERAL EMERGENCY MANAGEMENT AGENCY:

Pat Glithero
Hazard Mitigation Officer

Andrew Vlack
Disaster Recovery and Operations Specialist

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Hazard Mitigation Strategy for Federal Disaster #1237: 1998 Detroit Area Windstorm

MITIGATION STRATEGY
FEMA-1237-DR-MI
State of Michigan

OBJECTIVE

The objective of mitigation is to reduce future disaster losses through acquisition and relocation of hazard-prone property, structural retrofitting, mitigation education of community officials and residents, wise land use and land development practices, prudent use of resources and funding, and encouragement of National Flood Insurance Program (NFIP) implementation and compliance, to name just a few measures that have been successful. To assist communities in Michigan in their recovery from the straight-line winds and rain storms that struck Wayne and Macomb Counties on July 21-22, 1998, so that the rebuilt environment is safer and has a reduced risk from wind and flood damage, the following objectives must be accomplished:

1. Mitigation opportunities will be identified and selected:

   *The initial mitigation opportunities and recommendations identified during the damage assessment process in many of the affected communities include the following:

   a. A rebate program for local residents to buy NOAA weather radios.
   b. Community outreach and education to promote urban forestry practices.
   c. Community outreach to promote wind resistant construction techniques.
   d. Burying utility lines where appropriate and technically feasible.
   e. Building code enforcement.
   f. Acquisition and relocation or retrofitting and flood proofing (including elevation) of substantially damaged structures located in special flood hazard areas.

2. Financial resources, including disaster assistance programs such as the HMGP, PAGP and IFGP, and the funds from other state and federal programs, will be maximized:

   - Under the Public Assistance Grant Program, inspectors will make every effort to include mitigation efforts in reconstructing damaged properties and tree debris clearance.

3. Long-term mitigation will be ensured through comprehensive and prudent life saving measures (i.e., enhancement of early warning capability), urban forestry practices, local building practices, and floodplain management.

STRATEGY

The mitigation strategy for promoting and achieving mitigation of the hazards from this disaster will be focused in the following areas:

- Life safety measures.
- Community mitigation education and outreach.
- Coordination with the Public Assistance Grant Program.
- Community-administered structural retrofitting education and grant programs.
- Enhancement of urban forestry programs and practices.
- Mitigation project development.
- National Flood Insurance Program mitigation opportunities and promotion.
- Building and Infrastructure Design and Construction.

Life safety measures

- Assist community officials in identifying deficiencies in weather warning systems and come up with solutions that will ensure public safety is enhanced. (11/98)

Community mitigation education and outreach

- Coordinate with professional associations for groups such as building code officials and insurance companies for development of wind resistant building codes and practices. (11/98)

Coordination with the Public Assistance Grant Program

- Coordinate with the Public Assistance Grant Program (PAPG) staff to ensure that appropriate structural wind engineering and flood proofing measures are allowed and specified for public buildings and infrastructure being repaired under the Public Assistance Grant Program. (11/98)
- Coordinate with the Public Assistance Grant Program staff in creating mitigation measures that will reduce debris clearance. (11/98)

Community-administered structural retrofitting education and grant program

- Invite communities to establish and administer a locally-based structural retrofitting program that would provide public education on proper wind engineering techniques and components, and provide grants to individual home and business owners wishing to retrofit their structures to reduce future wind damage. The program could be implemented and administered by an existing local department, such as the building, planning or public works department, which would be responsible for disbursing grants, monitoring work, providing technical assistance, and providing program status to the State. (11/98)

Enhancement of urban forestry programs and practices

- Develop and provide guidance materials to forestry, public works, utility and other appropriate local departments on proper urban forestry techniques and practices. (11/98).
- Conduct workshops for home and business owners, design professionals and other interested parties, on proper tree selection and urban forestry techniques and practices. (11/98)
- In communities without an urban forestry program, encourage local officials to establish a program. (11/98)

Mitigation project development

- Information from the Preliminary Damage Assessment (PDA) will be used to help identify and select the communities which should be contacted concerning the possibility of mitigation opportunities under the Hazard Mitigation Grant Program (HMGP) (8/98) and other state and federal programs (9/98).
- Review the potentially damaged structure inventory from the PDA, concentrating primarily on structures that may have been substantially damaged. (9/98)
- Review the NFIP State Coordinator's information concerning the flood hazard identification and participation status of communities in the NFIP. (9/98)
- Coordinate with the Michigan Jobs Commission, the Michigan State Housing Development Authority, and other appropriate state agencies concerning communities with a substantial investment of state financial resources. (9/98)
- Whenever possible, incorporate mitigation projects into larger, ongoing or planned community projects (as long as the larger project will be completed in a timely manner and mitigation benefits can be fully retained). (Ongoing)

*Upon identification of communities suitable for mitigation, local officials will be contacted to determine the level of local interest in partnering toward recovery that will reduce the community's risk to future severe storms and flooding. The Mitigation Team will be activated and conduct site visits with communities to gain commitment in developing projects and implement appropriate mitigation measures. The Mitigation Team will function as a technical resource to the community to help identify the problem that should be addressed by the mitigation measure and identify financial assistance opportunities through federal, state and private sector programs.

NFIP mitigation opportunities and promotion

- MDEQ staff will provide technical assistance to local floodplain administrators as needed. (Ongoing)
- MDEQ staff will, as needed, conduct NFIP briefings to inform local floodplain administrators of NFIP responsibilities. (Ongoing)
- FEMA will mail letters to affected communities regarding immediate substantial damage determinations. (Not applicable for this disaster.)
- FEMA will identify priorities for possible enforcement actions. (Ongoing)
- MDEQ, EMD/MSP, and FEMA will review repetitive loss data for potential acquisition, elevation or flood proofing sites. (11/98)

*Even though this was primarily a wind disaster, flood mitigation objectives are included in this strategy as outlined in the Michigan Hazard Mitigation Plan.

Building and Infrastructure Design and Construction

- Enhance building codes to ensure public and private structures are more structurally sound to handle severe wind events. (11/98)
- Promote burying of utility lines in communities where it is appropriate and technically feasible. (Only public and non-profit utility companies are eligible for grant funding.) (11/98)

MITIGATION STRATEGY TEAM MEMBERS

STATE OF MICHIGAN

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FEDERAL EMERGENCY MANAGEMENT AGENCY

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Preliminary Damage Assessment

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Preliminary Damage Assessment

Hazard Mitigation Strategy for Federal Disaster #1226: 1998 West Michigan Windstorm

MITIGATION STRATEGY
FEMA-1226-DR-MI
State of Michigan

OBJECTIVE

The objective of mitigation is to reduce future disaster losses through acquisition and relocation of hazard-prone property, structural retrofitting, mitigation education of community officials and residents, wise land use and land development practices, prudent use of resources and funding, and encouragement of National Flood Insurance Program (NFIP) implementation and compliance, to name just a few measures that have been successful To assist communities in Michigan in their recovery from the straight-line winds that struck across Michigan on May 31, 1998, so that the rebuilt environment is safer and has a reduced risk from wind and flood damage, the following objectives must be accomplished:

1. Mitigation opportunities will be identified and selected:

   - The initial mitigation opportunities and recommendations identified during the damage assessment process in many of the affected communities include: retrofitting of wind-damaged structures with wind clips, fasteners and other bracing materials; urban forestry education; building code enforcement; acquisition and relocation or retrofitting and floodproofing (including elevation) of substantially-damaged structures located in special flood hazard areas; and structural modifications to water and sewer infrastructure to prevent flood damage.

2. Implementation of appropriate mitigation measures (projects) will be expedited:

   - Due to the nature of the damage and the obvious need to rebuild private residences and public facilities in a timely manner, there is a very narrow window of opportunity for achieving meaningful mitigation in the area of structural wind engineering (for damaged structures). Those projects and measures that relate to structural retrofitting of wind-damaged structures should be quickly approved so that these opportunities are not lost. This opportunity may be narrowed even further because most retrofitting may not be cost effective.

3. Financial resources, including disaster assistance programs such as the HMGP, PAGP and IFGP, and the funds from other state and federal programs, will be maximized:

   - Under the Public Assistance Grant Program, inspectors will make every effort to include mitigation efforts in reconstructing damaged properties, roads and drains. In addition, home and business owners should be strongly encouraged to use the available funding under the Small Business Administration's Disaster Loan Program to incorporate structural wind mitigation measures in the repair/reconstruction of their damaged structures. These programs have the ability to institute immediate, permanent mitigation measures on damaged structures and public infrastructure.

4. Long-term mitigation will be ensured through comprehensive and prudent life saving measures (i.e., enhancement of early warning capability), urban forestry practices, local building practices, and floodplain management.

STRATEGY

The mitigation strategy for promoting and achieving mitigation of the hazards from this disaster will be focused in the following areas:

- Life safety measures.
- Community mitigation education and outreach.
- Coordination with other disaster assistance programs.
- Community-administered structural retrofitting education and grant programs.
- Enhancement of urban forestry programs and practices.

- Mitigation project development.
- National Flood Insurance Program mitigation opportunities and promotion.

Life Safety Measures

- Assist community officials in identifying deficiencies in weather warning systems and come up with solutions that will ensure public safety is enhanced. (9/98)

Community mitigation education and outreach

- Coordinate with professional associations for groups such as building code officials and insurance companies for development of wind resistant building codes. (9/98)

Coordination with other disaster assistance programs

- Coordinate with SBA staff to ensure that appropriate structural wind engineering measures are allowed and specified for homes being repaired under the SBA Disaster Loan Program (using the 20% mitigation provision). (8/98)
- Coordinate with appropriate state and local officials to ensure that structural wind engineering measures are allowed and being implemented for homes being repaired under voluntary agency disaster relief and recovery programs.
- Coordinate with Public Assistance Grant Program (PAGP) staff to ensure that appropriate structural wind engineering and floodproofing measures are allowed and specified for public buildings and infrastructure being repaired under the PAGP. (8/98)

Community-administered structural retrofitting education and grant program

- Invite communities to establish and administer a locally-based structural retrofitting program that would provide public education on proper wind engineering techniques and components, and provide grants to individual home and business owners wishing to retrofit their structures to reduce future wind damage. The program could be implemented and administered by an existing local department, such as the building, planning or public works department, which would be responsible for disbursing grants, monitoring work, providing technical assistance, and prorating on program status to the State. (8/98)

Enhancement of urban forestry programs and practices

- Develop and provide guidance materials to forestry, public works, utility and other appropriate local departments on proper urban forestry techniques and practices. (9/98)
- Conduct workshops for home and business owners, design professionals and other interested parties, on proper tree selection and urban forestry techniques and practices. (9/98)
- In communities without an urban forestry program, encourage local officials to establish a program. (9/98)

Mitigation project development

- Information from the Preliminary Damage Assessment (PDA) will be used to help identify and select the communities that should be contacted concerning the possibility of mitigation opportunities under the Hazard Mitigation Grant Program (HMGP) and other state and federal programs. (7/98)
- Review the potentially damaged structure inventory from the PDA, concentrating primarily on those structures that may have been substantially damaged. (7/98)
- Review the NFIP State Coordinator's information concerning the flood hazard identification and participation status of communities in the NFIP. (7/98)
- Coordinate with the Michigan Jobs Commission and other appropriate state agencies concerning communities with a substantial investment of state financial resources. (8/98)
- Whenever possible, incorporate mitigation projects into larger, ongoing or planned community projects (as long as the larger project will be completed in a timely manner and mitigation benefits can be fully retained). (Ongoing)
- Upon identification of communities suitable for mitigation, local officials will be contacted to determine the level of local interest in partnering toward recovery that will reduce the community's risk to future sever storms and flooding. The Mitigation Team will be activated and conduct site visits with communities the commit to development of projects and implementation of appropriate mitigation measures. The Mitigation Team will function as a technical

resource to the community to help identify the problem that should be addressed by the mitigation measure and identify financial assistance opportunities through federal, state and private sector programs.

NFIP Mitigation Opportunities and Promotion

- MDEQ staff will provide technical assistance to local floodplain administrators as needed. (Ongoing)
- MDEQ staff will, as needed, conduct NFIP briefings to inform local floodplain administrators of NFIP responsibilities. (Ongoing)
- FEMA will mail letters to affected communities regarding immediate substantial damage determinations. (Not applicable for this disaster.)
- FEMA will identify priorities for possible enforcement actions. (Ongoing)
- MDEQ, EMD/MSP, and FEMA will review repetitive loss data for potential acquisition sites. (9/98)

*Even though this was primarily a wind disaster, flood mitigation objectives are included in this strategy as outlined in the Michigan Hazard Mitigation Plan.

MITIGATION STRATEGY TEAM MEMBERS

MICHIGAN
Doran Duckworth
Hazard Mitigation Coordinator

Dawn Schulert
Hazard Mitigation Officer

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National Flood Insurance Program Coordinator

FEDERAL EMERGENCY MANAGEMENT AGENCY
Dante Roveda
Hazard Mitigation Officer

Hazard Mitigation Strategy for Federal Disaster #1181: 1997 Southeast Michigan Tornadoes and Flooding

MITIGATION STRATEGY
FEMA-1181-DR-MI
State of Michigan

OBJECTIVE

The objective of mitigation is to reduce future disaster losses through acquisition and relocation of hazard-prone property, structural retrofitting, mitigation education of community officials and residents, wise land use and land development practices, prudent use of resources and funding, and encouragement of National Flood Insurance Program (NFIP) implementation and compliance, to name just a few measures that have been successful. To assist communities in southeast Michigan in their recovery from the severe storms that struck the area on July 2, 1997, so that the rebuilt environment is safer and has a reduced risk from wind and flood damage, the following objectives must be accomplished:

1. Mitigation opportunities will be identified and selected:

   - The initial mitigation opportunities and recommendations identified during the damage assessment process in many of the affected communities include: acquisition and relocation or retrofitting and floodproofing (including elevation) of substantially-damaged structures located in special flood hazard areas; structural retrofitting of wind-damaged structures with wind clips, fasteners and other bracing materials; structural modifications to water and sewer infrastructure to prevent flood damage; and urban forestry education.

2. Implementation of appropriate mitigation measures (projects) will be expedited:

   - Due to the nature of the damage and the obvious need to rebuild private residences in a timely manner, there is a very narrow window of opportunity for achieving meaningful mitigation in the area of structural wind engineering (for damaged homes). Those projects and measures that relate to structural retrofitting of wind-damaged structures should be quickly approved so that these opportunities are not lost.

3. Financial resources, including disaster assistance programs such as the HMGP, PAGP and IFGP, and the funds from other state and federal programs, will be maximized:

   - Every effort should be made to include structural wind retrofitting in the repairs and reconstruction done under the Temporary Housing Program (Minimal Repairs), the Individual and Family Grant Program, and the Public Assistance Grant Program. In addition, home and business owners should be strongly encouraged to use the available funding under the Small Business Administration's Disaster Loan Program to incorporate structural wind mitigation measures in the repair/reconstruction of their damaged structures. Appropriate flood mitigation measures should also be undertaken on those public facilities and infrastructure that incurred damage from flooding. All of these programs have the ability to institute immediate, permanent mitigation measures on damaged structures and public infrastructure.

4. Long-term mitigation will be ensured through comprehensive and prudent public health and safety measures (i.e., enhancement of early warning capability), floodplain management, urban forestry practices, and local building practices.

STRATEGY

The mitigation strategy for promoting and achieving mitigation of the hazards from this disaster will be focused in the following areas:

- Community mitigation education and outreach.
- Coordination with other disaster assistance programs.
- Community-administered structural retrofitting education and grant programs.
- Enhancement of urban forestry programs and practices.
- Mitigation project development.
- National Flood Insurance Program mitigation opportunities and promotion.

Community mitigation education and outreach

- Provide mitigation information in Disaster Recovery Information Centers. (7/21 till at least 8/1)
- Provide mitigation information by mail (upon request) as a follow-up to the Disaster Recovery Information Centers.
- Coordinate mitigation activities with the ongoing Community Relations Outreach Program.

Coordination with other disaster assistance programs

- Coordinate with Individual Assistance (IA) Program staff to ensure that appropriate structural wind engineering measures are allowed and specified for homes being repaired under the Minimal Repair Program.
- Coordinate with IA Program staff to ensure that appropriate mitigation measures are allowed and specified for recipients of IFG grants to prevent further damage to their homes from wind (such as removing trees that are in danger of falling onto the structure, providing additional bracing or tarping for damaged roofs and walls, etc.).
- Coordinate with SBA staff to ensure that appropriate structural wind engineering measures are allowed and specified for homes being repaired under the SBA Disaster Loan Program (using the 20% mitigation provision).
- Coordinate with IA Program staff to ensure that appropriate structural wind engineering measures are allowed and being implemented for homes being repaired under the American Red Cross and other voluntary agency disaster relief and recovery programs.
- Coordinate with Public Assistance Grant Program (PAGP) staff to ensure that appropriate structural wind engineering and floodproofing measures are allowed and specified for public buildings and infrastructure being repaired under the PAGP.

Community-administered structural retrofitting education and grant program

- Provide a block-grant to participating communities to establish and administer a locally-based structural retrofitting program that would provide public education on proper wind engineering techniques and components, and provide grants to individual home and business owners wishing to retrofit their structures to reduce future wind damage. The program would be implemented and administered by an existing local department, such as the building, planning or public works department, which would be responsible for disbursing grants, monitoring work, providing technical assistance, and reporting on program status to the State.

Enhancement of urban forestry programs and practices

- Develop and provide guidance materials to forestry, public works, utility and other appropriate local departments on proper urban forestry techniques and practices.
- Conduct workshops for home and business owners, design professionals and other interested parties, on proper tree selection and urban forestry techniques and practices.
- In communities without an urban forestry program, encourage local officials to establish a program.

Mitigation project development

- Information from the Preliminary Damage Assessment (PDA) will be used to help identify and select the communities that should be contacted concerning the possibility of mitigation opportunities under the Hazard Mitigation Grant Program (HMGP) and other state and federal programs.
- Review the potentially damaged structure inventory from the PDA, concentrating primarily on those structures that may have been substantially damaged.
- Review the NFIP State Coordinator's information concerning the flood hazard identification and participation status of communities in the NFIP.
- Coordinate with the Michigan Jobs Commission and other appropriate state agencies concerning communities with a substantial investment of state financial resources.
- Whenever possible, incorporate mitigation projects into larger, ongoing or planned community projects (as long as the larger project will be completed in a timely manner and mitigation benefits can be fully retained).
- Upon identification of communities suitable for mitigation, local officials will be contacted to determine the level of local interest in partnering toward recovery that will reduce the community's risk to future severe storms and flooding. The Mitigation Team will be activated and conduct site visits with communities that commit to development of projects and implementation of appropriate mitigation measures. The Mitigation Team will function as a technical resource to the community to help identify the problem that should be addressed by the mitigation measure, and identify financial assistance opportunities through federal, state and private sector programs.

NFIP Mitigation Opportunities and Promotion

- MDEQ staff will provide technical assistance to local floodplain administrators as needed.
- MDEQ staff will, as needed, conduct NFIP briefings to inform local floodplain administrators of NFIP responsibilities.
- FEMA will mail letters to affected communities regarding immediate substantial damage determinations.
- FEMA will identify priorities for possible enforcement actions.

Hazard Mitigation Strategy for Federal Disaster #1128: 1996 East Michigan Tornado and Flooding

DR-1128-MI

INTERAGENCY HAZARD MITIGATION TEAM REPORT

(Electronically reformatted version of original scanned document.)

[redacted]

Covering the Counties of: Bay, Lapeer, Saginaw, Sanilac, St. Clair, Tuscola and Midland

REGION V INTERAGENCY HAZARD MITIGATION TEAM MEETING REPORT

[redacted] [redacted]

August 27, 1996

in response to:

The June 21, 1996
Disaster Declaration for the State of
Michigan

FEMA-DR-1128-MI

Covering the Counties of: Bay, Lapeer, Saginaw, Sanilac, St. Clair, Tuscola and Midland

[redacted]

For additional information or additional copies of this report please write to:

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EXECUTIVE SUMMARY

On July 23, 1996, President Clinton declared that six counties, Bay, Lapeer, Saginaw, Sanilac, St. Clair, and Tuscola, were eligible for disaster assistance (FEMA -1128-DR-MI) in the State of Michigan due to widespread flooding caused by heavy rain. Midland County was added on July 31, 1996. All seven counties are eligible for Public Assistance, Hazard Mitigation, and as of August 15, 1996 Individual Assistance.

Prior to the declaration, in conjunction with local officials and the Michigan Department of State Police/Emergency Management Division (MDSP/EMD), the Federal Emergency Management Agency (FEMA) conducted Preliminary Damage Assessments (PDA) in the affected counties to document damages, identify possible mitigation measures and coordinate with local and state government officials. The result of the PDA indicated the damage to public infrastructure was in excess of $10,000,000.

Severe storms and torrential rainfall occurred from June 21 to June 23, 1996, with some areas receiving over five inches of rain in a 4 to 5 hour period, causing widespread flooding. On the evening of June 21, 1996, a tornado struck the City of Frankenmuth in Saginaw County.

An Interagency Hazard Mitigation Team meeting (IHMT) was held on August 8, 1996, in Bay City, Michigan, in order to develop appropriate mitigation strategies and recommendations with respect to this flooding event. The recommendations noted in this report extend from the IHMT meeting and are based on site visits, interviews with local officials, and information provided by other Federal and State agencies. The areas identified for mitigation are:

I. Planning and Land Use Management
II. Flood Insurance and Real Estate
III. Flood Proofing Existing Structures
IV. Drainage System Design, Construction and Maintenance
V. Road Design, Construction and Maintenance
VI. Forecasting and Emergency Response
VII. FEMA Flood Insurance Issue

Doran Duckworth
State Hazard Mitigation Officer

[redacted]

Part 1: Background Information

DISASTER DECLARATION

On July 23, 1996, President Clinton declared a major disaster (FEMA-DR-1128-MI) for Public Assistance and Hazard Mitigation in the State of Michigan due to severe storms. A Preliminary Damage Assessment (PDA) was conducted with the help of local jurisdictions, Michigan Emergency Management Division (MI EMD) and the Federal Emergency Management Agency (FEMA). The estimated public and private damage for this disaster exceeded $10 million.

Upon declaration, sections of the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Public Law 93-288, as amended, also known as the Stafford Act), took effect and provided for implementation of Federal disaster assistance programs.

Under Section 409 of the Stafford Act, an up-to-date State Hazard Mitigation Plan is required as a condition for Federal Disaster Assistance. This Interagency Hazard Mitigation Team Report and recommendations will serve as the foundation for updating the State Mitigation Plan. After further analysis, and with the full coordination of all affected state and local agencies, additional mitigation measures will likely be identified in the State Mitigation Plan.

PURPOSE OF THE REPORT

An Interagency Hazard Mitigation Team (IHMT) meeting was held on August 8, 1996, at the Bay City, Michigan, City Hall in order to develop appropriate mitigation strategies and recommendations with respect to this flooding event. This report is intended to outline opportunities for mitigating future losses for the seven Michigan counties which experienced severe storms, and heavy rains, a tornado and flooding during the period of June 21 to July 1, 1996. The declared counties are: Bay, Lapeer, Saginaw, Sanilac, Saint Clair, Tuscola and Midland. The recommendations noted in this report were developed at the IHMT meeting and are based on site visits, interviews with local public officials and information provided by other Federal and State agencies.

DESCRIPTION OF THE EVENT

A storm system moved through Michigan on a south easterly path during the end of June causing flooding in a large part of the state. (See Appendix B for a detailed description. See Appendix H and I for the National Weather Service (NWS) description of the weather event and Heavy Rainfall Events information.)

SUMMARY OF DAMAGES

FEMA Region I Federal / State teams were deployed to the field on August 23, 1996, as a result of a request for a Preliminary Damage Assessment from Governor Engler of Michigan. These teams surveyed the impact on public facilities and infrastructure as well as damage to private property. Most of the dollar value estimate of damages was to road systems and water control facilities drainage systems. A summary of the damage estimates, for category, that are eligible for assistance through Infrastructure Support, follows:

CATEGORY	FEMA/MEMD DAMAGE ESTIMATE ($)
Debris Clearance	272,900
Emergency Protective Measures	203,465
Road Systems / Non-Federal	3,722,325
Water Control Facilities	4,195,181
Public Buildings and Equipment	460,065
Public Utilities	64,950
Recreation and Other	561,150
TOTAL	**9,480,036**

The disaster declaration for the State of Michigan was requested as a result of damage to public facilities, private homes and businesses in several counties and cities in east-central Michigan. Severe storms and torrential rainfall occurred from June 21 to June 23, 1996, with some areas receiving over five inches of rain in a 4 to 5 hour period causing widespread flooding. The volume of water exceeded the capacity of the public drainage and sewer systems. Widespread flash flooding caused numerous road and bridge washouts, culvert failures, damage to drainage channels and flooding in homes in seven affected counties. In addition to the flooding, a tornado struck the City of Frankenmuth in Saginaw County on the evening of June 21. This tornado destroyed six homes and damaged 108 others, destroyed one business (a brewery that is critical to the town's tourism economy), damaged nine other businesses in the downtown area, and tore the roof off the public library. Debris was spread over several miles of city streets. Widespread power outages and natural gas leaks were reported. Two deaths and five injuries were directly attributed to the effects of severe weather.

Public Assistance

Preliminary Damage Assessments (PDA) conducted June 27 to June 29, 1996, indicated the most severe impacts were to roads, bridges, and drainage culverts and channels in Bay, Lapeer and Tuscola Counties. Tuscola County was particularly hard hit, with damages estimated to be over $4.5 million. Lapeer County suffered nearly $3 million in public damage, most of which was for washed out roads and bridges. Bay County had significant road damage estimated at nearly $1 million. Total public damage to date in the seven affected counties is $10,158,800. Of that amount, $8.8 million is for damage to roads, bridges, culverts and drainage channels. Over $700,000 has been spent on debris removal. Costs for emergency protective measures total nearly $340,000.

These figures are in addition to $1 million in damage to the Federal Aid System roads and bridges that will be covered under the Federal Highway Administration's emergency repair and reconstruction program.

Individual Assistance

Flooded home at northwest end of Cat Lake in Mayville, MI 6/22/96

Flooded home at east side of Cat Lake in Mayville, MI 6/22/96

On August 5, teams began collecting additional disaster survey information associated with private property losses. The flooding also caused widespread and significant damage to private homes and businesses throughout the area. In the City of Midland, in Midland County, over 960 homes were flooded, resulting in significant damage to mechanical systems and appliances in the basements. In St. Clair County over 650 homes received similar damage. In Bay County nearly 500 homes were damaged. In the seven county area, over 40 businesses were damaged by flooding. Many suffered major losses of inventory and equipment, in addition to the physical damage to their structures. Combined with the ten businesses that were damaged in the Frankenmuth tornado, the region suffered significant economic impact. The Individual Assistance Teams identified 2,860 homes that had been damaged by the flood and the tornado with a total damage of $15.3 million. On August 15, 1996, the President approved Individual Assistance (IA) for all seven counties.

(Note: Due to the IA declaration being declared several weeks into the PA disaster declaration, and the need to produce this report on a timely basis the final figures for IA are not entered in this report. As of September 12th over 3000 IA claims have been filed for the counties listed.)

Part 2: Past Recommendations and Mitigation Opportunities

STATE OF MICHIGAN HAZARD MITIGATION ACTIONS

National Mitigation Strategy

During the past four decades, the United States has experienced many natural disasters resulting in loss of life, injury and property damage. Public and private resources for recovery have been stretched to their limits. The nation is actively seeking ways to prevent or minimize damages caused by future natural hazard events.

In conjunction with its federal, state and local partners, as well as the private sector, FEMA has developed a National Mitigation Strategy which by the year 2010 aims to: 1) reduce significantly loss of life, injuries, economic costs and destruction of natural and cultural resources that result from natural hazards; and, 2) engender fundamental changes in perception so that the public demands safer communities in which to live and work.

Hazard Mitigation in the Stafford Act

Senator Robert T. Stafford saw the need to break the cycle of damage-repair-damage and sponsored an amendment to the Federal Disaster Relief Act (PL 93-288), the Stafford Act, to include mitigation as an integral part of federal disaster relief. Passed in 1988, the Stafford Act allowed FEMA to provide additional funding for hazard mitigation in the repair of permanent public facilities under its Public Assistance program (Section 406); and provide grants to state and local governments, eligible private non-profit organizations and Indian Tribes to implement additional hazard mitigation projects (Section 404). As a result, FEMA and the State of Michigan have developed a partnership with local communities, the private sector, universities and individual citizens to bread the damage-repair-damage cycle.

Michigan's Hazard Mitigation Plan

A statewide Hazard Mitigation Plan was developed after the Presidential declaration for flooding in 1986. The plan describes the State's vulnerability to natural disasters. Mitigation strategies to reduce or eliminate future damage in vulnerable areas are determined in order of priority by Michigan Emergency Management Division (MEMD), with assistance from FEMA and other Federal agencies. The State of Michigan has been engaged in implementation of this hazard mitigation strategy. That plan describes the measures that Federal and State agencies have undertaken to promote mitigation and presents a set of recommendations which are the basic for the State's mitigation efforts.

Breaking the Damage-Repair-Damage Cycle:

HAZARD MITIGATION STRATEGY FOR DR-1128-MI

August 5, 1996

The following strategy was developed as a guide for hazard mitigation planning for consideration from preliminary information compiled prior to the IHMTM, and projects associated with the Michigan disaster declaration DR-1128-MI. It forms an overall framework for more detailed recommendations and ultimately hazard mitigation projects that can be funded through the Hazard Mitigation Grant Program and other funding sources.

Education: Improved construction and maintenance practices

1. Prepare a Construction and Maintenance Manual for road and drainage construction and maintenance personnel. A suggested name for the publication could be Drainage Options Guide ("DOG"). This Manual will be designed for use by the Michigan Department of Transportation, Michigan County Road Association, Michigan River Basin Association; and County Drain Commissioners, and contain the following.

- Construction standards and simplified details for sizing, design of facilities, materials, installation methods for culverts, drainage ditches and bridges.
- Maintenance techniques and maintenance scheduling methods (planning for maintenance, funding issues, personnel issues, managing costs, etc.).

2. Hold training workshops to explain the use of the Construction and Maintenance Manual and, schedule workshops on an annual cycle for current and new personnel. Target the following groups for workshops: drainage district commissioners, road maintenance people (Department of Public Works etc.), contractors, farmers. The workshops could be associated with existing Michigan Department of Transportation (MDOT) training sessions.

Education: Land use planning and building permitting for hazard mitigation

1. Develop a Hazard Mitigation Planning Manual containing a description of planning procedures and model text that addresses hazard mitigation principles associated with land use planning and building inspection in the State of Michigan. Master planning and zoning opportunities for hazard mitigation would also be discussed. Emphasis should be placed on drainage issues and proper design for subdivisions and individual development sites. The manual would be useful to local planning officials, regional planning staffs and consultants offering architectural, engineering, landscape architectural and planning services.

Education: National Flood Insurance Program (NFIP) education opportunities for all those associated with the insurance aspect of floodplain management

1. Hold Insurance Agent workshops sponsored by the Michigan Department of Environmental Quality to provide information regarding program details, benefits of purchasing insurance, and the mandatory land management and building permit requirements associated with flood insurance availability. Computer Sciences Corporation (CSC), the NFIP insurance contractor for lenders and insurance agents, will be requested to hold additional training seminars in the declared area of the State of Michigan, in addition to the regularly scheduled sessions. The training will address all aspects of the NFIP.

Immediate and Short-term Initiatives

1. Hold an Interagency Hazard Mitigation Team meeting to further detail the mitigation opportunities outlined in the Strategy Report. ***(Note: This meeting was held on August 8, 1996.)***

2. The MEMD will coordinate with FEMA and use the available model document to prepare the hazard mitigation plan for FEMA's approval.

3. Pursue the development of projects for 404 funding through correspondence, meetings and phone calls.

- The State will notify local governments in writing of the availability of Section 404 hazard mitigation funds. Potential projects will be identified from information gathered by the State Hazard Mitigation Team as well as from PA inspectors and Damage Survey Report records. Communities and townships having unique hazard mitigation opportunities will be notified separately.

- The State should apply for administration funding to hire staff for the implementation of mitigation activities and to complete projects with 404 funding. The EMD will be responsible for soliciting and assisting applicants with the development of Section 404 projects.

4. Coordinate with Public Assistance (Infrastructure Support) to review Damage Survey Reports for mitigation opportunities. Encourage the development of mitigation projects associated with the Section 404 and 406 Programs. The State Hazard Mitigation Officer (SHMO) will coordinate with the State PA Officer to ensure that mitigation is stressed during briefings with public officials. The SHMO and State PA Officer may assist in the review of damage survey reports (DSRs) for mitigation opportunities.

- Areas of possible concern are drainage canals, water and waste treatment plants, and other governmental facilities and infrastructure. State Hazard Mitigation staff will work closely with FEMA and State Public Assistance (PA) staff to ensure that all eligible opportunities are explored and funded if possible.

Flood hazard reduction through acquisition, elevation and minimization

1. Promote the acquisition of repetitively flooded and substantially damaged properties through a voluntary flood-damaged property acquisition program. One of the few mitigation options available for this type of situation is to buy out the owners and remove the structures from the floodplain. Property acquisition programs are complex; information presented to affected individuals must be accurate and understandable.

2. Many areas experienced broad scale flooding (particularly Tuscola and Lapeer Counties); many structures may be situated where elevation of the building could be effective in reducing future flood losses. The elevation of utilities and appliances (minimization) can also be an effective mitigation technique for communities where broad scale flooding occurred in developed areas, i.e.: Midland, Port Huron, Bangor and Vassar.

Section 406 Hazard Mitigation Program: Incorporating Mitigation into Infrastructure Repairs

1. Following all Public Assistance (Infrastructure Support) Presidential disaster declarations, FEMA Region V produces hazard mitigation work sheets and guidance for field inspectors conducting Damage Survey Reports (DSR), so that mitigation will be considered for all Section 406 permanent public facility repairs. As a result of this proactive strategy, losses incurred in this severe storm and flooding event were greatly reduced.

MITIGATION OPPORTUNITIES

The FEMA Infrastructure Support programs, formerly Public Assistance (PA), now includes a mitigation component. Under this disaster recovery effort, Infrastructure inspectors are instructed to include mitigation measures in their Damage Survey Reports (DSRs) if appropriate and cost-effective. At the Applicant Briefings, local officials were encouraged to recommend mitigation projects to FEMA inspectors. If approved in the DSR, these mitigation measures are funded by the Section 406 program monies and state and local cost matches.

In addition to the Section 406 mitigation effort, Section 404 mitigation in this disaster declaration, DR-1128-MI, will provide an estimated $1,500,000 about 15% in Hazard Mitigation Grant Program (HMGP) funds to be matched on a 75% Federal/25% Applicant cost basis. FEMA will assist state and local officials in using these funds to implement new HMGP projects that are cost-effective and environmentally beneficial and will reduce or eliminate repetitive threats to citizens and their property. The HMGP in Michigan is managed by the Michigan State Police Emergency Management Division.

The June 21 to July 1, 1996 storm event resulted in the identification of seven areas of mitigation opportunities:

I. Planning and Land Use Management

II. Flood Insurance and Real Estate

III. Floodproofing Existing Structures

IV. Drainage System Design, Construction and Maintenance

V. Road Design, Construction and Maintenance

VI. Forecasting and Emergency Response

VII. FEMA Flood Insurance Issue

Utility Truck fording flood waters in Tuscola County

Note: These identified areas are discussed separately in the following pages, beginning with a statement of issues relative to the defined area, a description of background information, recommendations for further action, and lead and support agencies.

Michigan Mitigation Success Story

The South Branch of the Cass River Intercounty Drain is a 96,000 acre watershed in Lapeer and Sanilac counties. The Drain was originally established in 1901, and 28 miles were reconstructed in 1965 with the cooperation of Natural Resource Conservation Service (formerly SCS). The drain ranges in bottom width from 6 feet wide at the upstream end to over 50 feet wide in the downstream reaches, and the depth averages 12 feet. Minor maintenance and vegetation control was routinely done since the reconstruction. The state legislature raised the maintenance limit in the Michigan Drain Code in 1989 from an amount equal to $800 per mile of drain to $2,500 per mile of drain. Five years ago the drainage board authorized a complete physical inventory of the drain. Approximately $300,000 has been spent over the last five years for engineering and major maintenance. Landowners in the district report that flooding has been less and the length of inundation has been reduced. Landowners were extremely pleased with the drains performance at the end of June 1996. Water was out of bank as expected as a result of heavy rains, but flow returned within the banks within 48 hours and the system returned to normal flows within a week.

HAZARD MITIGATION ISSUES AND RECOMMENDATIONS

I. PLANNING AND LAND USE MANAGEMENT

ISSUE: Hazard mitigation opportunities are not included in local land use decisions.

BACKGROUND: State enabling legislation does not reference hazard mitigation as one of the objectives to be achieved through land use planning and management. In addition, community comprehensive land use plans generally do not address hazard mitigation issues and solutions. Comprehensive plans ordinarily address subjects that relate to the physical development of the community; there are no uniform required elements for comprehensive plans among the four basic planning enabling laws in Michigan. The content of most comprehensive plans developed for Michigan local governments is determined by the various planning commissions or the professional staff hired by the commission to develop the plan. Since mitigation is not a common topic, zoning and subdivision provisions do not invoke hazard mitigation opportunities during the review of development proposals at the local level.

RECOMMENDATION #1: LEGISLATION. Amend the Michigan State Enabling Legislation to incorporate "hazard mitigation" within the list of elements that comprise a comprehensive plan.

LEAD AGENCY: Hazard Mitigation Section, Emergency Management Division Michigan State Police.

SUPPORT AGENCIES: Michigan Department of Environmental Quality, Michigan Chapter of the American Planning Association, Michigan Society of Planning Officials, Michigan Department of Natural Resources.

ISSUE: Local development plans are approved without adequate consideration given to the drainage implications posed by the impervious soil surface coverage and/or by the existing upstream runoff.

BACKGROUND: The Michigan Planning Enabling Legislation provides that proposed subdivisions shall be reviewed by the County Drain Commissioner. The legislation, however, does not require a similar review of other types of land use change. This results in the construction of major impervious surfaces (roofs, parking lots) with very limited or uninformed review during the permit process. Since the County Drain Commissioner has knowledge of the culvert and bridge sizing, the Commissioner's office is a valuable step in the review process to monitor drain capacities and to set or approve culvert and bridge sizes. Also, through the use of hydrologic studies, the Commissioner can play an important role in minimizing flood damages when heavy runoff occurs. Excluding the Commissioner from a review role results in shortsighted decisions and a greater frequency of flooding, erosion and washout problems.

RECOMMENDATION #2: LEGISLATION: Amend the State Enabling Legislation to require that the County Drain Commission be included in the review and approval or disapproval of all land use change proposals as an integral step in the land development process for the State of Michigan. This review will include condominiums, development site plans and mobile home parks in addition to the existing review requirement for land subdivisions.

LEAD AGENCY: Michigan Department of Environmental Quality, Michigan Association of County Drain Commissioners (MACDC) and (MAC).

SUPPORT AGENCIES: Michigan Department of Agriculture, Emergency Management Division Michigan State Police and, Michigan Association of Conservation Districts.

ISSUE: Coordination of zoning for hazard mitigation to properly regulate land uses and structures in hazardous areas is lacking in many counties in Michigan.

BACKGROUND: State enabling legislation does not require coordination of zoning across local jurisdictions in order to perfect coordination of land use decisions affecting hazard mitigation. County zoning *per se* is permitted in Michigan, however, where municipal and township zoning is in effect county zoning *per se* is preempted. In this case, coordinated zoning across local jurisdictions is almost impossible without some sort of superimposed or overlay zoning. County zoning *per se,* or in the case where county zoning is preempted by municipalities and townships, county overlay zoning can achieve hazard mitigation objectives, as for example: building setback requirements and floodplain management in designated hazardous river and stream corridors, land use and traffic controls in designated hazardous transportation corridors, and land use and building construction controls in designated intercommunity hazardous areas.

RECOMMENDATION #3: LEGISLATION: Amend the Michigan county, municipal and township zoning enabling legislation to permit county overlay zoning of designated hazardous river and stream corridors, hazardous transportation corridors, and intercommunity hazardous areas.

ISSUE: The State of Michigan Hazard Mitigation Plan is being updated by the Hazard Mitigation Officer, Emergency Management Division, Michigan State Police. An update is required following every Presidentially declared disaster. The Michigan Hazard Mitigation Plan has not been updated since 1987. Updating the multi-hazard Michigan Plan will be a positive step as well as a valuable management tool for reducing damage resulting from future natural hazard events.

BACKGROUND: The importance of land use planning is recognized by the State of Michigan and is an important element in the preliminary Hazard Mitigation Strategy Report (see Appendix) developed prior to the Hazard Mitigation Team Meeting by FEMA Region V and the State Hazard Mitigation Officer. (The Hazard Mitigation Plan focuses on long term mitigation activity that would be most appropriate through an emphasis on planning). The plan describes existing activities related to hazard mitigation and legislation that establishes the foundation for management methods. Many recommendations are set forth to strengthen the role and awareness of hazard mitigation in planning activities; emphasis is placed on the integration of hazard mitigation into:

- basic land use/development regulatory mechanisms;
- state building codes;
- comprehensive planning process;
- model zoning text;
- subdivision control act;
- curriculum elements for urban regional planning students;
- training programs;
- future land use plans; and
- new land use legislation.

The Plan also recommends communication between local development regulators, planners and the Emergency Management Division.

RECOMMENDATION #4: PLAN IMPLEMENTATION. The Emergency Management Division should establish and coordinate a State Hazard Mitigation Council to address the mitigation recommendations found in the Michigan Hazard Mitigation Plan and to assure that the plan will be carried out in a coordinated and effective manner. This action is a recommendation in the State plan and should be designated as a high priority for implementation.

LEAD AGENCY: Emergency Management Division Michigan State Police.

SUPPORT AGENCIES: Local, state and federal agencies.

RECOMMENDATION #5: MITIGATION FUNDING. Establish a "State Hazard Mitigation Fund" to address the mitigation opportunities that are identified during flood events. The low interest loan program that was used to elevate floodprone structures along the Great Lakes shoreline in 1985 and 1986 should be reenacted and considered for use on a statewide basis. The State should accept some of the burden for flood loss mitigation, rather than rely solely on Federal assistance to correct flood problems.

LEAD AGENCY: Emergency Management Division Michigan State Police.

SUPPORT AGENCIES: Michigan Department of Environmental Quality, MDOT, and Consumer and Industry Services.

RECOMMENDATION #6: PROJECT LIST. Develop a list of potential mitigation projects within the State of Michigan. There is a general idea of the problem areas; however, communities, counties, and emergency managers should be contacted to obtain specific areas of concern. The contact would be made in the form of a

questionnaire or survey to gather input on potential projects, estimated costs and the benefits. The list would be prioritized based on cost/benefit, permit feasibility and funding.

SUPPORT AGENCY: Emergency Management Division of the Michigan State Police.

ISSUE: County hazard mitigation plans can complement the State of Michigan Hazard Mitigation Plan.

BACKGROUND: Not all the counties in Michigan have established county planning commissions to prepare county comprehensive plans in order to address hazard mitigation. To complement the State of Michigan Hazard Mitigation Plan, all Michigan counties should prepare hazard mitigation plans. These plans should be prepared as subcomponents of the state plan. County hazard mitigation plans can then be used to engage the counties in the coordination and implementation of state and county hazard mitigation strategies. The county hazard mitigation plans can also be used by county planning commissions as components of county comprehensive plans, thereby providing justification and validity for zoning and other controls for hazard mitigation.

RECOMMENDATION #7: PLAN IMPLEMENTATION. The Emergency Management Division of the Michigan Department of State Police should require and coordinate the preparation of county hazard mitigation plans as subcomponents of the State of Michigan Hazard Mitigation Plan. These county plans can also serve as components of county comprehensive plans for those counties that have established county planning commissions.

ISSUE: Local lay planners (Planning Commissioners) do not consider hazard mitigation when preparing community plans or when they review proposed development applications. New development occurs without evaluation of the potential danger or loss that could result when that new land use is affected by a natural hazard event.

BACKGROUND: Although local planning commissioners are encouraged to attend seminars and educational workshops given by the Michigan Chapter of the American Planning Association and the Michigan Society of Planning Officials, the current curriculum does not include hazard mitigation planning. This group of lay planners as well as building officials, community officials, emergency managers, developers, engineers, architects, and surveyors, should receive training in the considerations and benefits associated with planning for hazards. This issue is also addressed in the State Hazard Mitigation Plan that is referenced and endorsed elsewhere in this report.

RECOMMENDATION #8A: EDUCATION. Prepare a handbook for planning commissioners addressing the process for hazard mitigation planning at the local level. The handbook would be used as the text for training courses given on an annual basis.

LEAD AGENCY: Emergency Management Division, Michigan State Police.

SUPPORT AGENCIES: Michigan Department of Environmental Quality, other agencies and groups associated with land use management, MDA, and MACDC and Department of Consumer & Industry Services.

RECOMMENDATION #8B: EDUCATION: Initiate and or expand the training programs for planners to include hazard mitigation planning as a component of local comprehensive plans. This initiative would be sponsored and coordinated through the Michigan Society of Planning Officials with educational sessions and materials distributed through the professional and trade associations encompassing land change activity in Michigan. A partial list includes:

- **Michigan Townships Association**
- **Michigan Municipal League**
- **Michigan Association of Counties**
- **Michigan Chapter of the American Planning Association**
- **Michigan Society of Planning Officials**

- **Michigan Emergency Managers Association**
- **Michigan Association of County Drain Commissioners**

LEAD AGENCY: Michigan Department of Environmental Quality.

SUPPORT AGENCIES: Emergency Management Division Michigan State Police, and MDA.

II. FLOOD INSURANCE AND REAL ESTATE

ISSUE: Many home purchasers do not realize that their new property is prone to flooding.

BACKGROUND: The current disclosure laws in Michigan involving real estate transactions are vague, and provide little protection for the consumer.

RECOMMENDATION #9: LEGISLATION. Establish a provision in State law that requires the disclosure of floodprone areas as a step in real estate transactions. This should be mandatory regardless of the method of financing or financing institution.

LEAD AGENCY: Michigan Department of Environmental Quality.

SUPPORT AGENCIES: Emergency Management Division of the Michigan State Police.

ISSUE: There is a lack of information at all levels of the insurance industry about the National Flood Insurance Program (NFIP).

BACKGROUND: There is an on-going need to educate the realty, lending and insurance industry regarding flood hazards in general, and specifically the National Flood Insurance Program. Misinformation is being provided to property owners and buyers. Real estate, insurance and property inspection professionals need to be better educated about the NFIP program and its requirements.

RECOMMENDATION #10A: EDUCATION. Create improved instructional information for the National Flood Insurance Program. A revised NFIP booklet and other simple and effective communication materials are needed for the public as well as those who work closely with the program including insurance people, banking institutions/lenders, building inspectors and local planning officials. Other State handbooks could also be upgraded to include current floodplain management guidelines. The "Local Officials Handbook" prepared by the Department of Environmental Quality should include NFIP information.

LEAD AGENCY: Michigan Department of Environmental Quality.

SUPPORT AGENCIES: FEMA, NFIP Coordinator, Emergency Management Division Michigan State Police, State Insurance Industry, State Insurance Bureau.

RECOMMENDATION #10B: EXAMINATION. Flood insurance questions should be added to insurance qualification tests for agents and real estate personnel.

LEAD AGENCY: NFIP Coordinator, MDEQ, Department of Consumer & Industry Services.

SUPPORT AGENCY: FEMA, Michigan Emergency Management Division, Insurance Industry, Insurance Associations, State Insurance Bureau.

ISSUE: The public lacks knowledge of alternative insurance programs to assist them in recovering from a disaster.

BACKGROUND: The Michigan NFIP Coordinator's office has indicated that insurance agencies neglect to fully explain alternative insurance coverage that protects their clients from damage related costs after a disaster. The particular clients affected are in selected Michigan communities having a municipal sanitation and waste system. These systems historically have not kept up with the flow demand during disaster events. An insurance policy addressing sewage backup (policy attachment) would protect those homes in communities with waste treatment systems.

RECOMMENDATION #11: EDUCATION. An educational program for Insurance Agents should be initiated to address the need for selling specific policies for reimbursement of disaster costs.

LEAD AGENCY: NFIP Coordinator, Michigan Department of Environmental Quality.

SUPPORT AGENCIES: FEMA, Emergency Management Division Michigan State Police, Insurance Industry, Insurance Associations, State Insurance Bureau.

ISSUE: A number of structures in Michigan are located in flood prone areas and frequently experience damage during periods of high water.

BACKGROUND: Structures experiencing repetitive loss should be identified so that plans can be designed to reduce the recovery expense, and prevent future damages. The addresses of repetitive loss structures covered under the National Flood Insurance Program can be provided by FEMA. A method for addressing the losses would involve several steps: education for property owners, obtaining elevation information, and developing action plans for the properties.

RECOMMENDATION #12: REPETITIVE LOSS. Identify properties experiencing repetitive loss in Michigan. Priority projects for action that are identified through the property inventory will require additional funding either through a "State Hazard Mitigation Fund," Flood Mitigation Assistance Program funds or community funding.

LEAD AGENCY: Michigan Department of Environmental Quality.

SUPPORT AGENCIES: Emergency Management Division Michigan State Police, FEMA, US Army Corps of Engineers, Association of State Floodplain Managers, and the communities.

ISSUE: There is a need to update the floodplain maps that have been developed under the National Flood Insurance Program, and to have more communities in Michigan participate in the NFIP.

BACKGROUND: Many Michigan communities having significant floodplains do not have detailed floodplain maps. Others are in need of map revisions to identify development that has occurred since the maps were originally prepared. A priority listing is maintained which identifies the mapping needs by community. Current budgets at the Federal and State levels are not adequate to address the mapping needs in Michigan. Only about 40% of the communities in Michigan have been mapped for the NFIP. Only about 40% of the communities in Michigan (696 of 1776) are participating in the NFIP.

RECOMMENDATION #13: **FLOODPLAIN MAPPING. Mapping needs should be identified and prioritized. The Michigan Department of Environmental Quality (MDEQ) should develop a listing of unmapped communities and continue to identify floodprone areas. FEMA will continue to develop countywide maps within Michigan, following the priority listing developed by the MDEQ.**

LEAD AGENCY: Michigan Department of Environmental Quality.

SUPPORT AGENCIES: FEMA, US Army Corps of Engineers (USACE), Natural Resources Conservation Service, DNR, MDA, MACDC and MACD.

ISSUE: Orthophoto quadrangle maps and flood insurance maps can be digitized and overlaid providing an accurate depiction of the floodprone area.

BACKGROUND: The Michigan Department of Natural Resources is currently involved in a pilot program of overlaying digitized flood insurance rate maps onto digitized orthophoto quadrangle maps for Monroe County.

RECOMMENDATION #14: MAP OVERLAYS. The results of the digitizing program should be reviewed to determine its applicability to flood preparedness and mitigation. If the program is worthwhile, it should be expanded to the rest of the State.

LEAD AGENCY: Michigan Department of Natural Resources.

SUPPORT AGENCIES: Department of Environmental Quality, Emergency Management Division Michigan State Police, FEMA, MDA, MACDC, MACD, DNR.

III. FLOOD PROOFING EXISTING STRUCTURES

ISSUE: The general public has not been adequately informed of flood mitigation methods for existing structures. There are many opportunities for retrofitting homes and businesses in flood prone areas.

BACKGROUND: In many cases the general public learns about mitigation through retrofitting their homes following a disaster. Educational materials (handouts, public service notices and instructional courses) used in Disaster Recovery Centers for counseling disaster victims are an example of an effective means to inform the public. This information should be provided to the public prior to a disaster event.

RECOMMENDATION #15: EDUCATION. A public education program should be developed for retrofitting structures in flood prone areas. This information should be disseminated before a disaster occurs.

LEAD AGENCY: Emergency Management Division Michigan State Police.

SUPPORT AGENCIES: FEMA, MDEQ, NFIP Area Coordinators, County Emergency Management Coordinators, State Insurance Bureau, Insurance Associations, MSU Extension Service, Soil Conservation Districts.

IV. DRAINAGE SYSTEM DESIGN, CONSTRUCTION AND MAINTENANCE

ISSUE: Drainage ditches become damaged because of bank erosion and the lack of land use standards in the drainage corridors.

BACKGROUND: In order to maximize production, farmers commonly cultivate their land to the edge of the drain network. This practice weakens the banks and allows erosion to take place. Consequently the eroded material constricts the drainage system during a heavy rain event. By establishing a greenbelt of uncultivated land, a filter strip is created that can prevent bank erosion and excessive runoff from fields and crops. The green belt could be established through a "state setback standard" or the acquisition of a buffer on either side of drainage ditches.

RECOMMENDATION #16: LEGISLATION. Legislation is needed to establish a setback requirement for agricultural drainage ditches.

LEAD AGENCY: Michigan Department of Agriculture.

SUPPORT AGENCIES: Emergency Management Division of the Michigan State Police, Michigan Department of Environmental Quality.

ISSUE: Sediment deposition from surface water runoff and, more importantly, wind erosion, are major factors that reduce drainage system capacity. Reduced capacity contributes to the magnitude of the damage associated with a flood event. There are no state-wide standards to protect drainage systems.

BACKGROUND: Agricultural land suffers from wind and to a lesser degree, water erosion. As a result, sediment accumulates in the drainage system. The United States Department of Agriculture currently has two programs that address this problem. The Conservation Reserve Program and the PL-566 Land Treatment Watershed Program emphasize filter strips as a high priority. The 15-30 foot wide filter strips for water erosion can be grass that is mowed annually. Programs providing for a 15-30 foot wide natural buffer for wind erosion prohibit the operation of all machinery in the protected area. These programs pay the owner an annual maintenance fee. The programs require a minimum of 3 years and a maximum of 10 years for enrollment.

RECOMMENDATION #17: DRAIN BUFFERS. All drains in Michigan should be evaluated for the degree of sedimentation. Establish filter strips within the drain easement where impacted drains are identified. An effort should be made to determine if the effectiveness of the filter strips could be improved with an increase in width. Other strategies to increase the use, extent, effectiveness and permanence of the filter strips could include: 1) tax incentives, 2) direct payment, 3) reduced flood insurance premium, and 4) land acquisition by the drain commission.

LEAD AGENCY: Michigan Department of Agriculture.

SUPPORT AGENCIES: Association of County Drain Commissioners, Natural Resource Conservation Service, Local Conservation Districts.

ISSUE: Flood damage following heavy rains is becoming more common even though drains and drainage structures have been engineered using accepted runoff formulas.

BACKGROUND: When new development occurs, the runoff characteristics of the original parcel are changed due to the addition of impervious surfaces. This alteration increases stormwater runoff and the flow through drains, culverts and bridges. Adequately sized drains can, over time, become undersized due to the more rapid and increased flow caused by watershed development. No study exists to set standards for sizing structures and to limit site coverage for runoff management in the east central Michigan environment of dense soils and flat topography.

RECOMMENDATION #18A: SITE RUNOFF STUDY. Conduct a study of Michigan land character and its influence on storm water runoff. This pilot study will be a first step in the development of a land coverage formula for the State of Michigan based on soil character. The study should be designed with the objective to establish a formula for calculating the maximum land coverage for impervious surfaces. Soil characteristics, slopes and vegetation types will be considerations in the development of the maximum lot coverage methodology. This procedure would be used by engineers, land planners and local planning officials in the design and review of new development. Managing the impervious surface coverage of development parcels will help to reduce the high flow regimen in drainage structures and thus preserve the efficiency of the drainage system during major storm. The study should consider the feasibility of establishing a requirement that any land use change will be designed to assure that no net increase in runoff will occur as a result of the proposed land development.

LEAD AGENCY: Michigan Department of Agriculture.

SUPPORT AGENCIES: Michigan Department of Environmental Quality, Michigan Chapter of the American Planning Association, Michigan Society of Planning Officials, possibly other township, municipal and county associations, MACDC and MACD.

RECOMMENDATION #18B: LEGISLATION. Amend the Planning Enabling Legislation to require that development proposals include an analysis of runoff potential and soil characteristics to establish a maximum property coverage for impervious surfaces. This requirement must be based on accepted standards developed through a study of Michigan land and runoff characteristics. (see Issue and Background #17A as related).

LEAD AGENCY: Michigan Department of Environmental Quality.

SUPPORT AGENCIES: Michigan Department of Agriculture, MACDC and MACD Michigan Department of Environmental Quality, Michigan Chapter of the American Planning Association, Michigan Society of Planning Officials, possibly other township, municipal and county associations, MACDC and MACD.

ISSUE: Segments of the watershed are managed individually with minimal coordination between upstream and downstream watershed legal entities. Unanticipated flooding occurs due to upstream development and the resultant rapid run-off. Hydrologic information is not created or shared between counties to assist in the design of community infrastructure.

BACKGROUND: It is difficult to predict future flow requirements in a downstream county. Unplanned development may occur in upstream locations that results in increased storm water runoff beyond the calculated and anticipated normal flow rate. In addition, many counties do not have current hydrologic studies that would predict the runoff leaving a particular area given a designated storm event. This information would be very valuable for the construction of bridges, culverts and drains (ditches). Currently, standard sizing formulas are used to design new structures. Unfortunately, storms can overtop new structures due to the larger than anticipated runoff from upstream locations and from the lack of coordination between upstream and downstream watershed locations.

RECOMMENDATION #19: LEGISLATION: Amend the Michigan State Planning Enabling Legislation to require cross jurisdictional hydrologic planning between legal entities within watershed units (counties, cities, townships, villages, drainage districts). Designate this coordinated planning as a prerequisite for accepting State funds in the State's jurisdictions.

LEAD AGENCY: Michigan Department of Environmental Quality, Land & Water Management Division.

SUPPORT AGENCIES: Michigan Department of Natural Resources, Emergency Management Division Michigan State Police, and MDA.

ISSUE: Increasing flood damage results from upstream land development. Drainage districts do not have a program that evaluates the adequacy of current drain structures and establishes a plan and schedule for upgrading drainage structures.

BACKGROUND: Over time, as development and the addition of impervious surfaces occurs in the watershed, runoff increases. Adequately designed drains, culverts and bridges are unable to accommodate the increased flow that results during a storm. Hydrologic studies that calculate watershed runoff have not been completed and therefore cannot be used by the counties and Planning Commissions.

RECOMMENDATION #20: WATERSHED STUDY. Conduct a watershed hydrologic analysis to determine the adequacy of the existing drain capacity given the development pattern and a series of standard storm events. Also

conduct the watershed hydrologic analysis using a land buildout scenario developed through the distribution of the currently allowed zoning ordinance densities. With this information in hand a capital improvement program could be formulated to upgrade the existing infrastructure and establish a schedule for future upgraded replacement of drain structures. Replacement projects can be coordinated with the progress of watershed development.

LEAD AGENCY: Michigan Department of Agriculture.

SUPPORT AGENCIES: Michigan Department of Environmental Quality, Michigan Association of Drain Commissioners.

ISSUE: There is a lack of specific drainage design standards that are tailored for use in each of the Michigan drainage jurisdictions. Because of the variability in soil type and upstream runoff conditions, and since funding for research is limited, only broad standards exist for guiding drainage engineering and subsequent construction.

BACKGROUND: The current drainage system has evolved since its original construction in the 1800s. Because of watershed development, the original drain system may not be adequate to handle current flood events. Repairs and maintenance, when necessary, have been limited to restoring the drain network to its original construction specifications. Drain improvements require a petition to the Drain Commissioner and partial funding by the abutters. There seems to be adequate funding available for regular maintenance of drains once they have been brought up to the currently accepted standards. Drain design standards that are recognized by all drainage districts have not been developed and adopted. There is a lack of coordination between the various agencies that impact the drain systems.

RECOMMENDATION #21: DRAIN DESIGN STANDARDS AND EDUCATION. Develop and adopt minimum standards for drain design and construction. A state-wide watershed management standard must be adopted in order to apply a uniform specification for drain design and installation throughout the watershed. This standard must be developed to address peak flow rates and peak volumes. Develop a mechanism to coordinate all agencies that impact the drain system. A drainage design and maintenance course should be created for Drain Commissioners and their staffs based on the established drain standards. This training can be combined with the construction and maintenance handbook and the education program described in Recommendation #25.

LEAD AGENCY: Michigan Department of Agriculture.

SUPPORT AGENCIES: Association of County Drain Commissioners, Natural Resource Conservation Service, Michigan Department of Environmental Quality.

V. ROAD DESIGN, CONSTRUCTION AND MAINTENANCE

ISSUE: Serious and repetitive damage is occurring to roads because of a lack of universally accepted road design and construction standard.

BACKGROUND: The road system currently has several jurisdictions. The Interstate System is designed for flow rates to the 100 year event. Some officials responsible for local road construction are inadequately trained. There currently exists statewide training workshops for road commissioners, drain commissioners, construction and maintenance staff of counties, cities and towns, and Michigan Department of Transportation (MDOT) personnel. This training is provided through the County Road Association of Michigan (CRAM). CRAM promotes higher efficiency in the operation of the county road systems in Michigan by fostering the education of the membership and the general public.

- CRAM conducts annual meetings and conferences, schools and study courses for the discussion of county road matters.
- CRAM maintains a central bureau of information and research for the collection, analysis and dissemination of

information pertinent to county road matters through the publication and circulation of bulletins, papers and articles of interest and benefit to the membership.

- CRAM encourages legislation beneficial to the county road commissions of Michigan and the traveling public.
- CRAM furnishes consultant services and advice on all phases of county road activities.

The training is provided by the Michigan Technological University (MTU) and its affiliate: "T-Square;" the Local Technical Assistance Program in Houghton, Michigan. T-Square sends out a quarterly newsletter, maintains a video library, and holds educational workshops throughout the State.

RECOMMENDATION #22: ROAD DESIGN STANDARDS AND EDUCATION. Prepare a construction and maintenance manual for road and drainage construction personnel. The manual could be named "Drainage Options Guide" (DOG). A mandatory annual training program for all road construction and maintenance officials should be established, using the DOG manual as a text. All Road Commissioners should be required to design and construct their roads based on the Michigan Department of Environmental Quality (MDEQ) standards. The workshops should also incorporate the recommendations made by the Road Infrastructure Mitigation Committee following the 1986 flood disaster. The manual should emphasize that the key to reducing serious repetitive flood damage to the local, county and state transportation infrastructure is through a cooperative, innovative and coordinated effort at all levels of government. The design standards of county drain commissioners, the county road commissions, MDOT, and MDEQ are not necessarily the same. These standards must be spelled out in the manual to reduce the confusion among the transportation agencies and the public in general. The manual should also emphasize that MDEQ permits are needed for road crossings of all watercourses including designated county drains.

LEAD AGENCY: Michigan Department of Transportation, Michigan Department of Environmental Quality and Michigan Department of Agriculture.

SUPPORT AGENCIES: Training organizations: CRAM, MTU, T-Square.

VI. FORECASTING AND EMERGENCY RESPONSE

ISSUE: County drain commissioners lack information about proper emergency procedures.

BACKGROUND: An effective coordination of emergency response efforts between the County Emergency Management Coordinator and the County Drain Commissioners does not exist in all areas of Michigan. The drainage commissioners often lack specific emergency information and strategies that may be of some benefit during a flood event.

RECOMMENDATION #23: EDUCATION. Develop a training program for drain commissioners addressing their role in a flood emergency situation. Establish a mechanism to encourage the cooperation of County Emergency Management Coordinators with the County Drain Commissioners, i.e. an annual exercise between County Emergency Management Personnel and the County Drain Commissioners. Establish a training program for Drain Commissioners and their staffs.

LEAD AGENCY: Emergency Management Division Michigan State Police.

SUPPORT AGENCIES: Michigan Association of County Drain Commissioners and MDA.

ISSUE: There is a lack of real-time rainfall and river flow gage data in the areas of recent flooding and in Michigan in general. This has hindered the development of an effective flood warning system for Michigan.

BACKGROUND: At present, much of the precipitation data available to NOAA is gathered by volunteers. During the recent storm, rainfall reports were received only once every 24 hours or when a volunteer observed "significant" rainfall.

This system limited the effectiveness of flood forecasting. Many rain events occur at night when volunteer observers are not reporting rainfall data. This storm occurred during the hours of 9 pm and 3 am, June 21-22.

NOAA indicates that forecasting and providing warnings for floods is greatly hindered by the lack of automated real-time rainfall data. To forecast a flood it is vital to obtain rainfall intensity data in real-time, to ascertain rainfall rates per hour. Current 24 hour period readings are useful for long-term climatic studies, but do not help NOAA predict and warn when a flood is imminent.

Real-time data, that is, data that NOAA can receive as it is actually being collected, is essential for flood forecasting. Rain gages can be outfitted with a transmitter that will send data directly to NOAA via telephone modem or a device that transmits data via a radio or satellite connection. Hourly data is necessary to broadcast accurate flash flood warnings.

Presently there are no automated river gages in Michigan other than those located at airports. NOAA is planning to install one automated river gage in Midland in a secure area owned by Dow Corning. NOAA and the National Weather Service are being funded to install new state-of-the-art forecasting equipment, but do not have funds for data collecting equipment that would provide data for more accurate flash flood forecasting.

During the 1986 flood, concerns were raised regarding the coordination of flood warning information, and the lack of information. Michigan still does not have an effective flood warning system.

RECOMMENDATION #24: WARNING PLAN. Identify funding sources and take the necessary steps to install real-time rain and flow gages in Central Michigan. Develop an action plan that establishes an effective flood warning system for Central Michigan.

LEAD AGENCY: Michigan Department of Environmental Quality.

SUPPORT AGENCIES: NOAA National Weather Service, US Geological Survey, Emergency Management Division Michigan State Police, County and local emergency coordinators, dam owners, volunteer, media and MDA.
ISSUE: The migration of hazardous materials following a spill is difficult to predict since the location of flow routes has not been recorded and distributed to local emergency officials.

BACKGROUND: The extensive network of drains throughout the declared counties allows pollutants to flow for long distances within and between jurisdictions. When a pollutant enters the drainage system it is difficult for local officials to predict the downstream impacts of a migrating pollutant charge. No single document has been prepared showing the location and flow direction of the drain network in Michigan. Having the map available could assist in warning property owners and communities downstream (down drainage) that a hazardous charge was flowing toward a specific location or general area. A map would also improve the efficient interception of pollutants so that the hazardous materials could be removed.

RECOMMENDATION #25: MAPPING FOR DISASTER RESPONSE. Prepare and distribute detailed maps showing drains and their flow direction as well as transportation routes to assist with disaster response actions associated with liquid pollutants. Drain routes should be part of the county road maps provided by each road commission. They should be incorporated into county land use and zoning maps.

LEAD AGENCY: Emergency Management Division Michigan State Police.

SUPPORT AGENCIES: Michigan Department of Agriculture, Michigan Department of Environmental Quality.

VII. FLOOD INSURANCE ISSUES

ISSUE: There is a need to address the problems of agricultural losses due to flooding damage. The lack of adequate crop insurance alternatives for farm businesses is another problem that affects Michigan farmers.

BACKGROUND: Farmers have experienced damage and loss to crops due to flooding for many years. The 1993 Midwest floods caused the federal government to recognize the need to redesign the agricultural crop insurance program. In the past, for agricultural disasters, the federal government provided two separate programs - the federal crop insurance program and ad hoc disaster payments. Neither program worked well for farmers.

The new law, the Federal Crop Insurance Reform Act of 1994, combines the old USDA crop insurance program and the disaster assistance programs administered by the Agricultural Stabilization and Conservation Service (ASCS) into one program. Under the new law, farmers are required to obtain at least the catastrophic level of crop insurance coverage to participate in other USDA programs. Farmers may purchase "additional" crop insurance coverage with greater levels of protection against crop loss from private insurance agents.

Although these new programs are inexpensive, farmers and agricultural professionals feel that because of the yield formulas and price levels set for crops, farmers are not getting adequate insurance coverage although the policies are affordable. It is estimated that these policies will cover about 40% of a crop loss.

Currently, the NFIP program does not consider a farm crop an eligible item for insurance coverage. Reconsideration of this policy and inclusion of crops under the NFIP program would greatly assist the recovery of the agricultural industry following a flood.

RECOMMENDATION #26: LEGISLATION. The FEMA Region V Mitigation Division and the Michigan State Flood Insurance Coordinator should develop a written request to the Federal Insurance Administration suggesting that they consider initiating a program for flood insurance coverage for farm crops. The justification for the need for such coverage should be documented in the request or the ASCS Crop Insurance Program should be expanded to help rectify this situation.

LEAD AGENCY: FEMA or USDA.

SUPPORT AGENCIES: State legislators, MDEQ, NFIP Coordinators, Michigan Insurance Industry, Michigan Insurance Bureau, Farmers Association, Michigan Department of Agriculture.

ISSUE: Land use regulations do not restrict development below dam sites.

BACKGROUND: Current building code and NFIP requirements do not consider the "hydraulic shadow" of a dam failure when determining the flood hazard impacts. A dam failure can produce flood elevations and velocities that are considerably higher than naturally occurring flows.

RECOMMENDATION #27: POLICY. A nationwide policy addressing development downstream of dams should be drafted and incorporated into the NFIP regulations.

LEAD AGENCY: Michigan Department of Environmental Quality.

SUPPORT AGENCIES: Emergency Management Division Michigan State Police, FEMA, Association of State Floodplain Managers, Association of State Dam Safety Officials.

ISSUE: There is continual improvement of structures in the floodway that perpetuates a hazardous condition.

BACKGROUND: There is a need to obtain the opinion of the Michigan Attorney General on the phrase "assure that the channels and the portions of the floodplains that are the floodways are not inhabited". The current interpretation is that the improvement does not represent a new occupation of the floodway. Further, there is some question as to the definition of "inhabited."

RECOMMENDATION #28: LEGAL OPINION. Obtain the Michigan Attorney General's legal opinion of the Michigan state regulations pertaining to floodway habitation. If a more stringent interpretation is provided, develop a strategy for administering the updated directive.

LEAD AGENCY: Michigan Department of Environmental Quality.

SUPPORT AGENCIES: FEMA.

ISSUE: There are a number of unfunded mitigation opportunities from previously declared disasters.

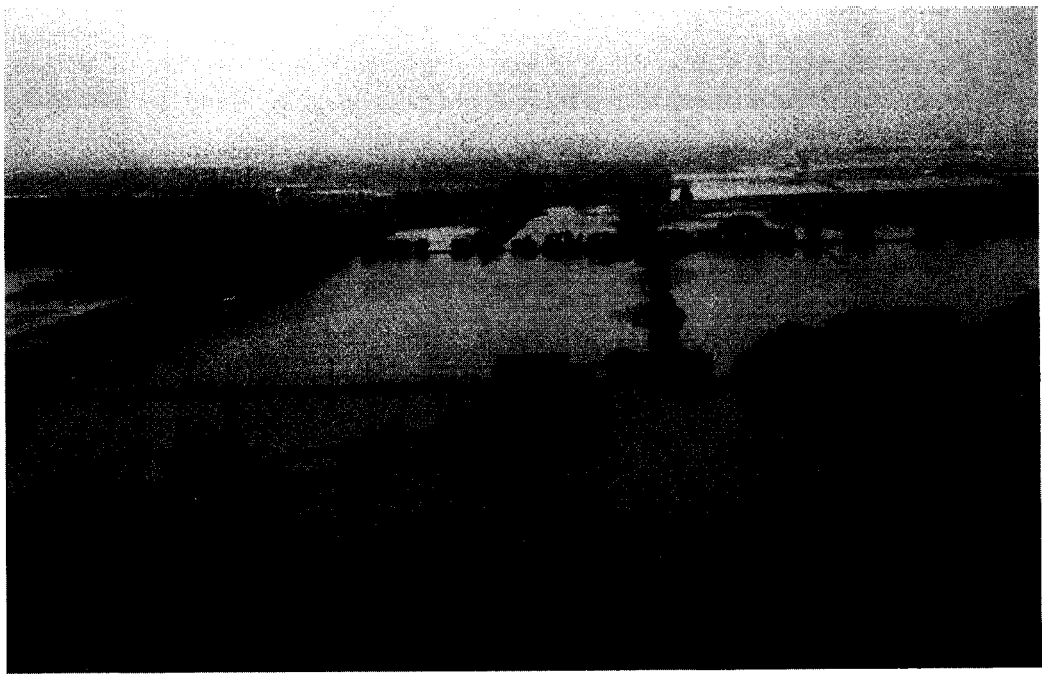
Note: See Appendix A for review of previous disaster recommendations.

BACKGROUND: Several initiatives suggested in previous hazard mitigation strategies/plans remain unfunded or still to be implemented. Acquisition and relocation of many structures in the City of Vassar is an example of an earlier recommendation that has not been fully completed because of inadequate funds and a lower community priority.

RECOMMENDATION #29: PAST MITIGATION PROJECTS. The Vassar project and other potential hazard mitigation projects should be reviewed for action and, if appropriate, incorporated into the Michigan Hazard Mitigation Plan. See the Appendix A for issues and recommendations from the 1986 Disaster Plan that should be evaluated for implementation.

LEAD AGENCY: Michigan Department of Environmental Quality.

SUPPORT AGENCIES: Emergency Management Division Michigan State Police.



Flooding in Tuscola County Agricultural Area

APPENDIX A
1986 Mitigation Recommendations

Appendix A is an excerpt from the Report following the September 1986 flood disaster (FEMA DR-774-MI). It is included in this report as part of the background for recommendation #29.

D. FLOODPLAIN MANAGEMENT

As is often the case, information is lacking pertaining to the wise use of floodplains and coastal flood zones, the availability and coverage of Federal flood insurance, the implications and implementation of local floodplain management ordinances, and the use of maps, where available. These recommendations are offered in order to improve the awareness of available information and programs.

8. Work Element: Increase public awareness of the NFIP.

Background: In many instances, local officials, insurance agents, and community residents were unaware or misinformed about the NFIP. Workshops should be held to describe the NFIP, including eligibility requirements and availability of flood insurance, and the existence of flood insurance maps and their interpretation. For insurance agents, the existing program needs to be reviewed and updated to better inform insurance agents about the NFIP. Flood insurance questions should be added to insurance agent qualification tests. A program should also be developed to review and monitor federally regulated lenders to ensure that flood insurance is purchased and maintained for identified floodprone properties.

Lead Agency: FEMA, MDNR, MDSP-EMD, and the banking industry

Financing: FEMA and MDNR

Schedule: 180 days

10. Work Element: The State of Michigan should sponsor an annual "Flood Awareness Week."

(NOTE: Work Element Number 10 has been done.)

Background: The Michigan Department of State Police, Emergency Services Division has established tornado and winter storm awareness weeks. The events of this disaster indicate the need for a statewide public education campaign for floods. This program should include wide distribution of maps identifying those areas susceptible to flooding.

Lead Agency: MDSP-EMD and NWS

Financing: Existing budget

Schedule: 180 days

E. AGRICULTURE

Agriculture is an appropriate use of the floodplain, however, significant losses frequently occur which can be reduced. This event in Michigan is no different except that the cumulative losses are staggering: in excess of $250 million and rising. Continual, extensive, excessive rainfall has saturated the ground resulting in standing water occurring in areas miles from identified floodplains. Crops, ready for harvest, are not accessible and are rotting in the fields. Farmers, already battling a difficult economic environment, are left with loans from spring planting with no yield to balance their

debt. This may be the last financial catastrophe many can endure. As many as 22% of the farmers in the declared counties are expected to declare bankruptcy.

As a follow-up to an Interagency Hazard Mitigation Team Report in South Dakota (FEMA-717-DR-SD, June 1984), a state by state investigation was made of existing programs to reduce agricultural farm losses. While some measures can be taken (crop selection, storage sites, and insurance) to reduce losses from low magnitude, frequent events, nothing could be found to be effective given the current meteorological situation in Michigan. The Team offers these recommendations in hopes of reducing future agricultural losses from lesser events.

11. Work Element: The State of Michigan should establish design, construction, and maintenance guidelines for dikes and levees protecting agricultural land.

Background: The Team visited several sites where agricultural levees failed. It appeared that privately owned dikes and levees were improperly located and poorly designed, constructed, and maintained. While designed to protect from lesser magnitude floods, the Team noticed that many may have failed in any event. Developed guidelines should include the following considerations: foundation, structural, embankment, hydraulics and hydrology, interior drainage, storm design frequency, construction inspection, operations, and maintenance with special attention to tree and brush removal.

Lead Agency: MDNR and Michigan Department of Agriculture (MDA) with technical assistance from USACE and SCS.

Financing: Legislature Schedule: 90 days

12. Work Element: Review mechanisms available for providing technical assistance in non-project areas for farmsteads located in the 100-year floodplain for floodproofing (e.g., ring dikes and elevated structures).

Background: Not only were there extensive crop losses throughout the declared disaster area, over 1,200 farm houses and other structures were flooded. The Team felt that a review of existing programs might identify additional potential financial assistance. Policies might be changed where necessary, and increased education of program delivery agencies and local participants could lead to the availability of greater protection.

Lead agency: USDA, FEMA (on national level), Agricultural Stabilization and Conservation Service (ASCS), Farmers Home Administration (FmHA) SCS, MDA, and MDNR.

Financing: To be determined Schedule: 180 days

13. Work Element: Review existing programs to revise or redirect ongoing assistance efforts to adequately provide disaster coverage to the farm community and to incorporate mitigation measures.

Background: The Team felt that existing emergency programs do not adequately assist farmers during major disaster declarations, and that they do not address mitigation measures such as protection or loss reduction.

Lead Agency: USDA, extension services, Farm Bureau, National Milk Producers Association, and National Farm Organization.

Financing: None required Schedule: 180 days

F. ADDITIONAL RECOMMENDATIONS

In addition to the recommendations offered thus far, the Team recognized several areas that with some attention could greatly reduce the impacts of a similar event. Specifically, the protection of sewage treatment facilities, enforcement of existing codes, and the review of certain design standards are addressed in this section. Each topic is addressed by a single recommendation, though there are myriad components to each suggestion.

13. Work Element: Create a multi-disciplinary task force to evaluate flood damage to and caused by the failure of sewage handling systems.

Background: Throughout the disaster area, flooding caused damage to sewage handling systems, which in turn caused additional damages. This task force should review existing guidelines and revise/develop new ones, as necessary. These should address, at a minimum, the following functional areas:

- auxiliary power for lift stations and treatment facilities
- site locations and related floodproofing requirements
- adequacy/necessity of storage/holding basins and related design criteria
- minimizing infiltration and/or inflow, including separation of stormwater and sanitary systems, disallowing footing and roof drains to empty into sanitary systems, and identifying building code changes where appropriate
- criteria for determining optimum level of floodproofing/protection in relation to storm frequency/cost effectiveness
- maintenance, operations and emergency plans to minimize flood damage
- post-flood recovery operations plans and policies.

Lead Agency: MDNR, MDSP-EMD, Michigan Public Health, EPA, EDA, FEMA, and USAGE.

Financing: Initially within existing budgets Schedule: 90 days

15. Work Element: Increase awareness of floodplain management code standards, ordinances, and procedures with local elected officials, building code officials, and floodplain residents.

Background: As Interagency Teams have identified nationwide, and almost continually, lack of enforcement of existing codes and regulations often leads to a significantly greater exposure to flood hazards. In Michigan, awareness of the NFIP minimum requirements and building code requirements needs to be strengthened. Confusion and lack of knowledge of floodplain elevations, floodway designations. And procedures necessary to enforce code requirements (e.g., substantial improvements) is inhibition loss reduction mechanisms in some flood damaged areas. Among the suggestions put forth toward, improving enforcement were:

- evaluate resource requirements for NFIP enforcement
- expand local building inspector training awareness programs
- develop procedures and definitions to clarify the enforcement of substantial improvement requirements
- propose legislation to require identification of floodprone parcels on title abstracts (public disclosure)

Lead Agency: FEMA-Federal Insurance Administration, MDNR, MDSP-EMD, Michigan Department of Labor-Construction Code Division and Code Officials Association

Financing: Operating budgets Schedule: 90 days

APPENDIX B

DESCRIPTION O F THE EVENT

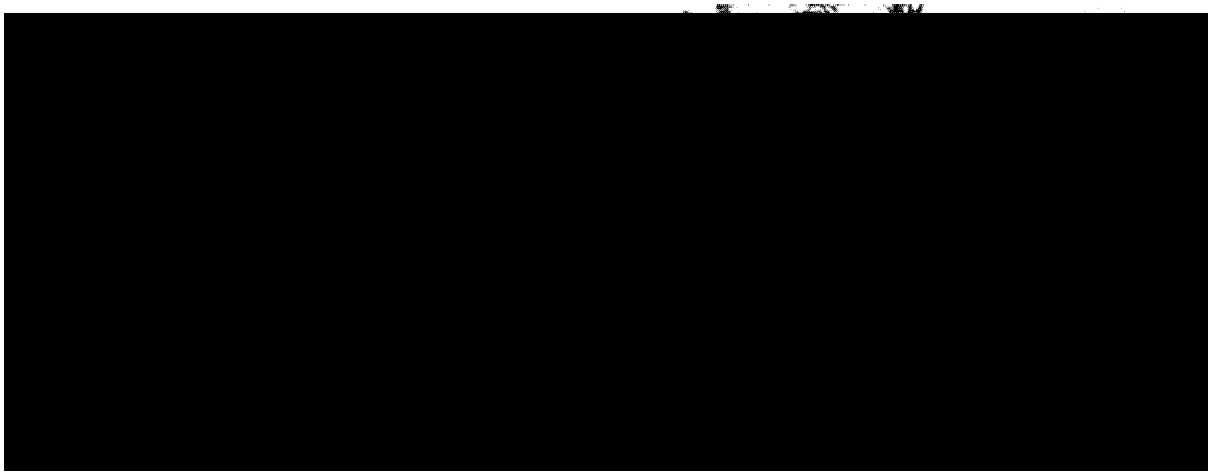
During the day on Friday June 21, 1996, an east-west front across southern Lower Michigan slowly advanced north. Showers and strong to severe thunderstorms were occurring across Wisconsin. A severe thunderstorm watch was issued for most of southern Michigan for the afternoon and into the evening. The storms over Wisconsin were moving

southeast but continued to dissipate as they moved into Michigan. The watch was eventually canceled around 6 PM based on a lack of any significant weather.

By 8 PM, the warm front extended southeast across central Lower Michigan from a low pressure center in northeast Wisconsin. The front was approximately positioned across Mason, Lake, Mecosta, Isabella, Midland, Saginaw, Genesee, Lapeer and St. Clair Counties. It continued to move slowly north. No precipitation was detected by radar across this area between 6 PM and 9PM. Just after 9 PM, a thunderstorm developed along the warm front over Osceola County. As the storm moved southeast along the warm front, additional storms developed into a multiple storm complex that was approximately 70 miles long and 30 miles wide. The storms intensified over Isabella County and continued moving southeast.

Numerous funnel clouds were reported with these storms with two confirmed tornadoes, one in Frankenmuth in Saginaw County and one north of Yale in St. Clair County. These storms also produced torrential rains falling at the rate of 1 to 3 inches per hour. A 15 mile wide band of three to five inches of rainfall extended from approximately the City of Midland to Bay City then southeast through Vassar in Tuscola County into northeast Lapeer County and than St. Clair County. The 3 hour flash flood guidance, which is a number produced by the river forecast center in Minneapolis that represents an average amount of rainfall needed to initiate flash flooding, ranged from 2.0 inches in St. Clair County to 2.7 inches in Tuscola County. Most of this heavy rain fell in a 2 to 3 hour time period.

A flash flood watch was issued for the area in question around 9:30 PM, June 21. The whole storm event occurred between 9 PM and 3 AM. Also, river flood warnings for the Cass River at Frankenmuth and the Saginaw River at Saginaw continued from rains which occurred earlier in the week. New flood warnings were issued for the Cass River at Vassar and the Flint River at Flint that night.



Tornado Damaged Streets in Frankenmuth

Hazard Mitigation Strategy for Federal Disaster #1028: 1994 Northern Michigan Deep Freeze

Hazard Mitigation Plan for

1994 Northern Michigan Severe Cold Weather Infrastructure Disaster (FEMA 1028-DR-MI)

Covering the Counties of:
Charlevoix
Cheboygan
Chippewa
Delta
Gogebic
Houghton
Mackinac
Marquette
Ontonagon
Schoolcraft

Prepared by:

Emergency Management Division
Department of State Police
(Doran B. Duckworth, State Hazard Mitigation Officer)

with assistance from

Division of Upper Peninsula / Division of Water Supply – Michigan Department of Public Health

Surface Water Quality Division – Michigan Department of Natural Resources

Office of Federal Grants / Community Development Block Grant Program – Michigan Department of Commerce

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I. INTRODUCTION

A. Authority. This hazard mitigation plan has been prepared by the Michigan Department of State Police, Emergency Management Division (EMD), to fulfill the State of Michigan's responsibilities under Section 409 of P.L. 93-288, as amended (The Robert T. Stafford Disaster Relief and Emergency Assistance Act). This plan has been developed as the result of the May 10, 1994 Major Disaster Declaration by the President (FEMA-1028-DR-MI) covering the following 10 counties: Charlevoix; Cheboygan; Chippewa; Delta; Gogebic; Houghton; Mackinac; Marquette; Ontonagon; and Schoolcraft.

B. Purpose. The purpose of this plan is to outline opportunities to reduce or mitigate the potential for future cold weather-related infrastructure damage and losses in the areas covered by the Disaster Declaration. Some aspects of the plan go beyond the declared area by pointing out problems that are statewide in nature. The uniqueness of this disaster and the possibility that a similar event could occur in other cold weather states suggests that some issues could be addressed at the national level as well.

C. Scope. This plan will describe the infrastructure disaster, damages caused, costs incurred, problems identified, existing mitigation measures in the affected area, and mitigation opportunities. The mitigation opportunities include the opportunities identified in the Hazard Mitigation Survey Report, as well as those identified after the report was published.

D. Goals and Objectives. Mitigation goals for this disaster, as stated in the Hazard Mitigation Survey Report, are as follows:

1. Improve state and local ability to reduce threats to life and safety posed by severe cold weather.

2. Reduce the vulnerability of existing utility systems to severe cold weather.

3. Avoid damage to future public utility systems.

Specific objectives to be achieved for these goals are as follows:

- Improve capabilities to predict severe cold weather periods which may hamper operation of water and sewer systems, and to take appropriate actions to prevent system freeze ups and damage.

- Ensure all future construction, alterations and repairs to water and sewer systems adhere to state codes and standards and system master plans.

- Integrate mitigation into long-range capital improvements planning to identify and implement preventive measures for vulnerable system components.

- Where appropriate, improve state codes and standards to better address the problems associated with frost damage caused by severe cold weather.

II. BACKGROUND

A. Description of Disaster. The severe cold weather infrastructure disaster occurred as the result of a combination of record low temperatures (beginning in December 1993 and extending through mid-February 1994), and the lack of snowfall on the ground in many areas that traditionally serves as **a** natural insulator to buried water and sewer lines. The severe cold weather that the region experienced was caused by a jet stream pattern going from north of Alaska, back south through the Great Plains, to the Gulf Coast. This allowed Arctic air masses that normally remain over Hudson Bay to move across the Great Lakes Region and prolong the sub-zero temperatures.

These conditions caused unusually deep frost to permeate the ground, which froze and/or broke over 3,200 water and sewer lines and disrupted water and sewer service to approximately 18,700 homes and businesses. Thousands of residents had to keep water running in order to prevent pipes from freezing and bursting. In some locations in the Upper Peninsula, the frost line was **as deep as 96 inches**. Normally, the frost line depth ranges from 52-66 inches during the period **in** which the damage occurred. Typically, municipalities in the affected region have their water lines buried at an average depth of 72 inches (6 feet).

The freezing conditions, which began in early December, continued through the first week of May. Even when the air temperatures reached above freezing, the frost did not leave the ground at the depths of the water and sewer pipes in some areas until late May or early June. The type of soil, amount of snow cover, amount of sunshine reaching the soil, and the location of pipes caused some variation in this condition.

Frozen water and sewer lines and low water pressure caused public health and safety concerns throughout the declared area. Frozen/broken water lines left many residents without **an** adequate and reliable source of safe water for drinking and household uses. Many residents were without normal water supply for various periods of time ranging from a day or two to several weeks. Temporary measures such as the use of water tankers, pipes laid on the ground, and garden hoses between homes were used to distribute water in those areas where water mains or lateral lines to residences could not be thawed. Frozen/broken water lines and low water pressure also severely hampered firefighting capability, leaving many communities without adequate fire protection for several weeks. Several homes were destroyed by fire during this period of low water pressure. Low or negative water pressure also increased the possibility of water line contamination, resulting in boil water orders being issued on several occasions as a safety measure.

B. **Cost of Disaster.** In addition to the significant infrastructure damage and public health/safety impacts, this disaster placed a tremendous financial burden on the affected communities. None of the hardest hit communities had the financial resources necessary to repair or reconstruct the damaged infrastructure. Several communities faced severe cash-flow problems due to the disaster. Public works departments had to rent or buy specialized equipment, such as backhoes with special buckets, high amperage welding machines, thawing machines, jackhammers, generators, air compressors, etc., to thaw and repair frozen or broken lines. Communities also had to replace pumps and pipes much sooner than originally scheduled. In addition, many of the smaller public works departments had to contract for the specialized technical engineering expertise needed to effectively cope with the disaster conditions and necessary repair/mitigation efforts.

Initial damage estimates by the affected communities indicated approximately $7 million in total damage to public infrastructure. Table 1 provides a breakdown of initial public damage estimates by type of damage:

Table 1

	Initial Estimates of Public Damage (by type of damage)	**Totals**
A	Debris Removal	$7,000
B	Emergency Protective Measures	$1,635,000
C	Road Systems	$355,000
D	Water Control Facilities	$0
E	Public Buildings/Related Equipment	$26,000
F	Public Utilities	$5,071,000
G	Other	$0
	TOTALS	**$7,094,000**

As of the end of June, 1994, actual Public Assistance Grant Program (PAGP) funds expended under Section 406 of the Stafford Act are summarized in Table 2:

Table 2

	Public Assistance Funds Expended (by type of damage)	**Totals**
A	Debris Removal	$0
B	Emergency Protective Measures	$1,955,714
C	Road Systems	$320,740
D	Water Control Facilities	$53,429
E	Public Buildings/Related Equipment	$2,067
F	Public Utilities	$3,043,594
G	Other	$0
	TOTALS	**$5,375,544**

Included in the Table 2 totals are funds for mitigation measures required as a condition of receiving public assistance funds. The majority of these measures involved insulating repaired/replaced lines, and replacing vulnerable system components with stronger or better-designed components. Mitigation measures not funded under the Public Assistance Grant Program may be eligible for funding under the Hazard Mitigation Grant Program (HMGP). See Section V (A) (1).

III. PROBLEM IDENTIFICATION

A. Cause of Damage. The infrastructure damage in northern Michigan was caused by a combination of factors, including: unusually long sub-zero freezing weather conditions; lack of insulating snowfall in some areas which allowed frost to permeate the ground to record depths; and vulnerable water and sewer system components due to age, system design, type of material used, depth and location of lines, lack of insulation, or a combination of these factors.

Frozen and broken water/sewer lines were the primary problem in this disaster. Typically, when water and sewer lines are installed, they are buried at a depth that falls below the normal frost line for the area in question. In northern Michigan, most communities have their water lines buried at an average depth of 6 feet (72 inches). Normally, that depth is adequate to prevent lines from freezing on such a wide-scale basis.

However, the record depth frosts experienced from December 1993 to May 1994 caused lines that would normally be safe to freeze. As water freezes within the line, it expands and cracks the pipe, causing leaks, reduced water pressure, and possible contamination. The cracked pipe must then be repaired with a sleeve device or, if the damage is severe enough, replaced in its entirety.

Many communities in the northern United States experience frozen and/or broken infrastructure components every winter; however, the widespread and severe nature of this situation - the fact that whole systems were affected - makes this not only a unique disaster, but also a difficult one to mitigate.

B. Reason for Damage. The main reason for the damage was the record frost depths that caused water and sewer lines to freeze and break. This resulted in over 3,200 frozen and/or broken lines across the affected area. In most cases, the depth that the lines were buried was adequate and up to current standards. It is not economically feasible to retrofit entire existing water and sewer systems against this type of situation. If the right combination of weather conditions occur again, it is likely that an infrastructure disaster similar to this one may also occur again. Frost depths of 96 inches, in this area of the country, are unprecedented. It would be both technically difficult and extremely expensive to require water and sewer lines to be buried below that depth.

However, it is both feasible and prudent to protect those vulnerable components of a system that, because of their location, size, or material, are more prone to freezing and breaking than others. Also, replacements and new additions to a system should be done in accordance with state codes and standards, and be consistent with approved system master plans.

C. Potential for Future Damage. As stated above, similar weather conditions, resulting in similar frost depths, would probably result in similar types of damage. Obviously, this would depend on a number of factors. However, because of the knowledge gained from this unique disaster, it is doubtful that a similar disaster of this magnitude would occur. Preventive steps, such as letting water run from the onset of extended freezing conditions and keeping pipes thawed, would hopefully prevent such a widespread and severe impact. It would be difficult, if not impossible, as well as economically infeasible, to protect entire water and sewer systems from this type of damage. Vulnerable system components, however, can be strengthened and protected.

IV. EXISTING MITIGATION MEASURES

A. Federal Measures. Michigan's public water supplies are regulated under the Federal Safe Drinking Water Act (P.L. 93-523, as amended), and rules contained in 40 CFR Parts 141 and 142. The Michigan Department of Public Health (MDPH), as a primacy agency for the Federal government, provides supervision and control of Michigan's public water supplies, including their operation and physical improvements, under the Michigan Safe Drinking Water Act (Act 399, P.A. 1976).

Although the regulation, construction and operation of municipal sewerage systems is a state function in Michigan, the U.S. Environmental Protection Agency (USEPA) provides an important service via their Technology Transfer Program. Design manuals, operation manuals, and handbooks have been developed for the entire spectrum of wastewater treatment and collection system components and provided to states for their use. The publications are used by the Michigan Department of Natural Resources (MDNR), Surface Water Quality Division, to develop design review and operation procedures for their municipal wastewater

program. The regulatory aspects of the Federal Clean Water Act that pertain to municipalities have also been delegated to the MDNR. The National Pollutant Discharge Elimination System (NPDES) provides the regulatory authority under the Act and results in the issuance of comprehensive operating permits for all facilities that discharge to surface waters.

B. **State Measures.** The Michigan Department of Public Health, Bureau of Environmental and Occupational Health/Water Supply Division, regulates', through a permit process, the design, construction and alteration of public water supply systems. Water supply construction must be conducted within the framework of the Michigan Safe Drinking Water Act, and Public Act 240, P.A. 1937 (Architecture, Professional Engineering, and Land Surveying Act), which requires professional engineering preparation of construction documents for water works construction costing over $15,000. Most communities in the affected area have water system master plans that have been developed in coordination with MDPH.

The Michigan Department of Natural Resources, Surface Water Quality Division, assists communities with the development and maintenance of their wastewater treatment systems. The MDNR monitors and regulates these systems to ensure pollution abatement and health conditions are met for the communities these systems serve. The MDNR also administers a program of project review and permitting for the construction of sewerage systems, pursuant to Act 98, P.A. 1918, as amended.

C. **Local Measures.** All communities are required to adhere to state codes and standards governing the design, construction and alteration of water and sewer systems. Through the permitting process, the Michigan Department of Public Health reviews plans for altering community water systems, and the Michigan Department of Natural Resources reviews plans for altering community sewer systems.

Most communities have developed, and must adhere to, a water system master plan developed in coordination with the MDPH. All replacements and alterations to a community water system must conform to this plan, unless MDPH grants an exemption. For those communities that have not yet developed a water system master plan, MDPH will review proposed changes and make a determination for permit approval or denial based on established codes and standards, and generally accepted engineering practice.

For this disaster, both departments will assist communities with questions regarding permits, facility standards, proper sizing of lines, and techniques that will help resist frost damage in the future.

V. PROPOSED MITIGATION ACTIVITIES

A. Mitigation Measures in Declared Area.

1. Work Element: Decrease the vulnerability of those system components not directly affected by the disaster, or which were damaged but not covered under the Public Assistance Grant Program, but nonetheless could be susceptible to frost damage from a similar event in the future.

Background: In many communities, certain components of their water and sewer systems are vulnerable to frost damage, even though they were not damaged in this disaster. In addition, some components, even if damaged by the frost, did not meet the eligibility criteria for funding under the Public Assistance Grant Program. These projects should be considered for funding under the Hazard Mitigation Grant Program. HMGP funds can be combined with Community Development Block Grant (CDBG) or other sources of funds, through a community's capital improvements program, to implement preventive measures.

Lead Agency: Michigan Department of State Police/Emergency Management Division.

Financing: Hazard Mitigation Grant Program; existing budgets.

Schedule: Jurisdictions had until July 15, 1994, to submit Pre-Application Forms for proposed mitigation measures to EMD. A total of 62 project proposals were received, with funding requests totaling nearly $5.7 million dollars. FEMA set the total amount of available HMGP funding for this disaster at $669,539. On July 20, 1994, a State Selection Panel was convened to review, prioritize and approve project proposals for funding under the HMGP. A total of 21 projects were selected by the Panel for funding consideration. Applicants whose projects were chosen have until August 15, 1994, to submit a formal application to EMD. EMD will then submit a State Grant Application to FEMA, with the individual project applications attached. FEMA will review the individual project applications and provide a grant to the State for disbursement to those applicants whose projects are approved. In most situations, the grant process takes several months to complete. Any problems encountered with individual project applications (i.e., environmental concerns, questions

regarding cost-effectiveness of project, problem with required permits, etc.) will require additional time to resolve.

2. **Work Element:** Increase awareness of community officials about state codes and standards for water and sewer systems, and the permit processes for system alterations.

   Background: Increasing awareness of public works officials of MDPH/MDNR codes and standards for water/sewer systems, and the requirements for permits, will enhance future mitigation opportunities for frost-related system damage. By being familiar with the codes and standards and permit processes, local officials can work more cooperatively with MDPH/MDNR staff in designing alterations that are consistent with their system master plans (or if a master plan has not been developed, that meet current codes and standards) and better able to withstand frost damage.

   Lead Agency: Michigan Department of Public Health; Michigan Department of Natural Resources.

   Financing: Existing programs/budgets.

   Schedule: The MDPH has agreed to re-issue guidance to local communities specifying codes and standards that have to be met, permit requirements, and how those requirements may tie into potential mitigation measures for frost damage.

3. **Work Element:** Develop water system master plans for those communities that don't presently have one.

   Background: A water system master plan can help communities determine both short and long-range capital improvements priorities, and implement preventive measures for frost-related damage.

   Lead Agency: Michigan Department of Public Health.

   Financing: Existing programs/budgets.

   Schedule: Not determined.

4. **Work Element:** Provide technical assistance and encouragement to communities to apply for and use Community Development Block Grant funds for implementing mitigation measures.

   Background: The Michigan Department of Commerce (MDOC) administers the Community Development Block Grant Program for non-entitlement communities. One of MDOC's programs, the Rebuild Michigan Program, is directed towards renewing community infrastructure. This program may be available for restoring damaged water and sewer systems. A community may use these funds to help restore and upgrade those components of their system which are not being repaired under the Public Assistance Grant Program. In addition, these funds may serve as the local match for Hazard Mitigation Grant Program funds.

   Lead *Agency:* Michigan Department of Commerce; Michigan Department of State Police/Emergency Management Division.

   Financing: Community Development Block Grant Program for Rebuild Michigan Public Infrastructure.

   Schedule: The deadline for submitting applications to the MDOC Office of Federal Grants for 1994 projects is August 15, 1994. Funding decisions will be made by September 2, 1994. Information pertaining to 1995 funding will be sent out sometime in early 1995.

5. **Work Element:** Ensure that all water/sewer system repairs and mitigation measures funded under the PAGP and HMGP use appropriate cold weather engineering practices, and are consistent with state codes and standards.

   Background: *All* repairs and replacements funded under the PAGP for this disaster have been made, wherever possible, in accordance with state codes and standards and appropriate cold weather engineering practices. In addition, the MDPH and MDNR will review mitigation measures proposed for funding under the HMGP to ensure that they meet codes and standards and are consistent with approved system master plans.

   Lead Agency: Michigan Department of Public Health; Michigan Department of Natural Resources; Michigan Department of State Police/Emergency Management Division.

Financing: Existing programs/budget.

Schedule: Jurisdictions had until July 15, 1994, to submit Pre-Application Forms for proposed mitigation measures to EMD. A total of 62 project proposals were received, with funding requests totaling nearly $5.7 million dollars. FEMA set the total amount of available HMGP funding for this disaster at $669,539. On July 20, 1994, a State Selection Panel was convened to review, prioritize and approve project proposals for funding under the HMGP. A total of 21 projects were selected by the Panel for funding consideration. Applicants whose projects were chosen have until August 15, 1994, to submit a formal application to EMD. EMD will then submit a State Grant Application to FEMA, with the individual project applications attached. FEMA will review the individual project applications and provide a grant to the State for disbursement to those applicants whose projects are approved. In most situations, the grant process takes several months to complete. Any problems encountered with individual project applications (i.e., environmental concerns, questions regarding cost-effectiveness of project, problem with required permits, etc.) will require additional time to resolve.

6. Work Element: Increase awareness of community officials about state codes and standards for water and sewer systems, and the permit processes for system alterations.

Background: Increasing awareness of public works officials of MDPH/MDNR codes and standards for water/sewer systems, and the requirements for permits, will enhance future mitigation opportunities for frost-related system damage. By being familiar with the codes and standards and permit processes, local officials can work more cooperatively with MDPH/MDNR staff in designing alterations that are consistent with their system master plans (or if a master plan has not been developed, that meet current codes and standards) and better able to withstand frost damage.

Lead Agency: Michigan Department of Public Health; Michigan Department of Natural Resources.

Financing: Existing programs/budgets.

Schedule: The MDPH has agreed to re-issue guidance to local communities specifying codes and standards that have to be met, permit requirements, and how those requirements may tie into potential mitigation measures for frost damage.

7. Work Element: Develop water system master plans for those communities that don't presently have one.

Background: **A** water system master plan can help communities determine both short and long-range capital improvements priorities, and implement preventive measures for frost-related damage.

Lead Agency: Michigan Department of Public Health.

Financing: Existing programs/budgets.

Schedule: Not determined.

8. Work Element: Provide technical assistance and encouragement to communities to apply for and use Community Development Block Grant funds for implementing mitigation measures.

Background: The Michigan Department of Commerce (MDOC) administers the Community Development Block Grant Program for non-entitlement communities. One of MDOC's programs, the Rebuild Michigan Program, is directed towards renewing community infrastructure. This program may be available for restoring damaged water and sewer systems. A community may use these funds to help restore and upgrade those components of their system which are not being repaired under the Public Assistance Grant Program. In addition, these funds may serve as the local match for Hazard Mitigation Grant Program funds.

Lead Agency: Michigan Department of Commerce; Michigan Department of State Police/Emergency Management Division.

Financing: Community Development Block Grant Program for Rebuild Michigan Public Infrastructure.

Schedule: The deadline for submitting applications to the MDOC Office of Federal Grants for 1994 projects is August 15, 1994. Funding decisions will be made by September 2, 1994. Information pertaining to 1995 funding will be sent out sometime in early 1995.

9. **Work Element:** Ensure that all water/sewer system repairs and mitigation measures funded under the PAGP and HMGP use appropriate cold weather engineering practices, and are consistent with state codes and standards.

Background: All repairs and replacements funded under the PAGP for this disaster have been made, wherever possible, in accordance with state codes and standards and appropriate cold weather engineering practices. In addition, the MDPH and MDNR will review mitigation measures proposed for funding under the HMGP to ensure that they meet codes and standards and are consistent with approved system master plans.

Lead Agency: Michigan Department of Public Health; Michigan Department of Natural Resources; Michigan Department of State Police/Emergency Management Division.

Financing: Existing programs/budget.

Schedule: Representatives from the MDPH and MDNR were part of the State Selection Panel which prioritized and selected projects for funding under the HMGP. A technical review of all proposed mitigation projects was made by MDPH/MDNR as part of the selection process. Projects that are not consistent with state codes and standards and appropriate cold weather engineering practices will not be funded under the HMGP.

B. <u>Statewide Mitigation Measures</u>.

1. **Work Element:** Incorporate appropriate cold weather engineering practices into state codes and standards for the design, construction and alteration of public water and sewer systems throughout the state.

Background: Although this disaster affected only portions of northern Michigan, any community in the state could potentially be affected by a similar event. Therefore, state codes and standards for water and sewer systems should be revised as needed to incorporate appropriate cold weather engineering practices.

Lead Agency: Michigan Department of Public Health; Michigan Department of Natural Resources.

Financing: Existing programs/budget.

Schedule: The MDPH and MDNR will review existing water and sewer system codes and standards to determine adequacy of cold weather provisions. A result of this review may be a revision to the codes and standards.

2. **Work Element:** Establish formal "let run" policies and procedures to keep water moving through a community's system to prevent freezing during periods of extended or extreme cold weather.

Background: Letting water run continuously through a community's water system can be an effective tool in preventing widespread water and sewer line freezeups. However, the state does not have a formal policy or procedures for initiating "let run" actions. As it stands now, each community can initiate and terminate its own "let run" actions. These actions can vary greatly from community to community. Development of formal policies and procedures by the MDPH/MDNR would provide communities with some guidelines for "let run" situations, and help ensure that "let-runs" do not adversely impact water and wastewater treatment operations.

Lead Agency: Michigan Department of Public Health; Michigan Department of Natural Resources.

Financing: Existing programs/budget.

Schedule: This project should be done in conjunction with item B 1 above.

3. **Work Element:** Work with the National Weather Service, Army Corps of Engineers Cold Regions Research and Engineering Laboratory, and other appropriate agencies to better identify periods of extended sub-zero weather which could lead to widespread water and sewer system freeze ups.

Background: Identifying periods in which widespread water and sewer system freeze ups are possible is the first step that must be taken to initiate "let runs" and other preventive actions. Research must be done to determine the combination of temperature range and duration that may lead to widespread water and sewer system freeze ups. Obviously, this will depend on a number of factors such as the

type, depth and location of pipe, soil conditions, temperature of water in pipes, etc. However, it may be possible to identify a set of conditions (similar to a weather watch) in which the likelihood of system-wide freeze ups in certain localities is greatly increased. Public works crews could then monitor frost levels more closely and the affected community, in conjunction with MDPH/MDNR and other appropriate agencies, could initiate appropriate preventive actions if line freeze ups appear likely.

Lead Agency: National Weather Service; Army Corps of Engineers/Cold Regions Research and Engineering Laboratory; Michigan Department of Public Health; Michigan Department of Natural Resources; Michigan Department of State Police/Emergency Management Division.

Financing: Existing programs/budgets, or possible Hazard Mitigation Assistance (HMA) funds.

Schedule: Not determined.

VI. PLAN IMPLEMENTATION/MAINTENANCE

A. <u>Implementation and Monitoring</u>. Responsibility for implementation and monitoring of this plan ultimately rests with the Commanding Officer of EMD, who is also designated as State Coordinating Officer for all disaster response, recovery and mitigation activities.

The State Hazard Mitigation Officer (SHMO) is responsible for coordinating and managing the day-to-day activities related to plan implementation, including working directly with other lead state agencies assigned tasks in this plan. Specific responsibilities of the SHMO and lead state agencies are outlined in items 1 and 2 below:

1. **Role of State Hazard Mitigation Officer.** Implementation of this plan involves coordination by the SHMO with those Federal, state and local agencies that have been designated as having responsibilities for implementing specific recommendations. The SHMO will assist the lead agencies in identifying, coordinating and obtaining the necessary resources required to implement each recommendation. This may involve conducting meetings or training sessions, assisting in background research, developing guidance or correspondence, making telephone calls, etc. The purpose of these efforts will be to stimulate interest and support for mitigation activities, and to solidify the involvement and commitment of the parties involved in implementation of the recommendation.

   The SHMO may request technical assistance and support from the Federal Hazard Mitigation officer or other agencies or organizations with expertise in the situation, to assist the State in carrying out its hazard mitigation responsibilities.

2. **Responsibilities of Lead Agencies.** Lead agencies are responsible for four main activities that can contribute to implementation of plan recommendations. These are:

   a. Educate colleagues within their respective agencies as to how the recommendations were formulated and why they are important. This may involve post-disaster meetings and/or training sessions with involved staff, creation of special task forces to address specific issues, development of specific guidance materials tailored to the agency and its role, or other similar activities.

   b. Identify and coordinate the technical, material and financial resources available from within their agencies or from other sources, necessary for implementation activities.

   c. Integrate implementation activities into work programs and schedules.

   d. Report to the SHMO on a quarterly basis regarding the status of activities undertaken or scheduled, resources committed, milestones achieved, areas of concern or barriers to progress, etc.

3. **Reporting Requirements.** Lead agencies will report to the SHMO, per item *2* (d) above. Each agency will have an individual designated for this purpose. The SHMO, in turn, will share this information with other involved agencies to keep them informed and involved in the process. The SHMO will monitor progress through phone calls, personal visits, meetings, written correspondence and other appropriate means. The SHMO will (as appropriate) submit an annual progress report on the status of plan implementation to the Federal Hazard Mitigation Officer. This progress report will indicate the status of each mitigation recommendation contained in the plan, describe any problems or issues that have developed, and include recommendations for additional, modified, or no action. Copies of the report will be provided to all involved agencies and officials.

B. **Evaluation.** The SHMO and involved agencies will evaluate the plan on at least an annual basis to determine the effectiveness of the plan recommendations, and to ensure that implementation has occurred as planned.

1. **Goals and Objectives.** Goals and objectives will be reviewed to determine if they are still applicable, and if they still correspond with state priorities. If not, they will be modified to reflect current conditions, capabilities, problems, resources, etc.

2. **Effectiveness of Mitigation Strategies and Measures.** Mitigation recommendations and strategies will be reviewed to determine if the desired outcomes have occurred as planned.. If not, the recommendation or strategy may have to be modified to reflect changes in capabilities, resources, or other factors pertinent to implementation. If agency coordination is a problem, the SHMO will attempt to meet with the appropriate officials to resolve coordination problems and improve lines of communication.

C. **Maintenance.** The SHMO will maintain this plan and make any necessary modifications.

1. **Plan Updates.** If additional mitigation recommendations are developed, or if revisions to any part of the plan are necessary, the SHMO will develop and distribute plan updates to all plan holders of record.

2. **Plan Expansion.** The SHMO is in the process of developing a generic all-hazards mitigation plan as part of the State's ongoing mitigation efforts. The plan is being developed as a work product under the Disaster Preparedness Improvement Grant (DPIG) Program funded through the Comprehensive Cooperative Agreement with FEMA. The plan is being jointly developed by the SHMO and the State Hazard Mitigation Team. Completion is expected in early 1995.

   This disaster-specific Section 409 hazard mitigation plan will be incorporated into the generic, all-hazard plan as an attachment. At the time of the next Presidential disaster declaration for Michigan, it is anticipated that the generic, all-hazard mitigation plan will only require minor modifications to meet the planning requirements of Section 409 of the Stafford Act. A supplemental report will be developed to address new hazard mitigation needs or issues, reprioritize existing recommendations, or expand the plan to address new/additional hazards.

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Hazard Mitigation Strategy for Federal Disaster #774: 1986 Central Michigan Flooding

MICHIGAN FLOOD HAZARD MITIGATION PLAN

September 1986 Flood Disaster

Prepared by

Land & Water Management Division
Department of Natural Resources
and
Emergency Management Division
Department of State Police

APRIL 1987

Flood Hazard Mitigation Plan for

September 1986 Flood Disaster (FEMA 774-DR-MI)

Covering the Counties of
Allegan, Arenac, Bay, Clare, Clinton, Genesee, Gladwin,
Gratiot, Huron, Ionia, Isabella, Kent, Lake,
Lapeer, Macomb, Manistee, Mason, Mecosta, Midland,
Montcalm, Muskegon, Newaygo, Oceana, Osceola,
Ottawa, Saginaw, Sanilac, Shiawassee, Tuscola,
and Van Buren

Prepared By
Land and Water Management Division Department of Natural Resources

and

Emergency Management Division Department of State Police

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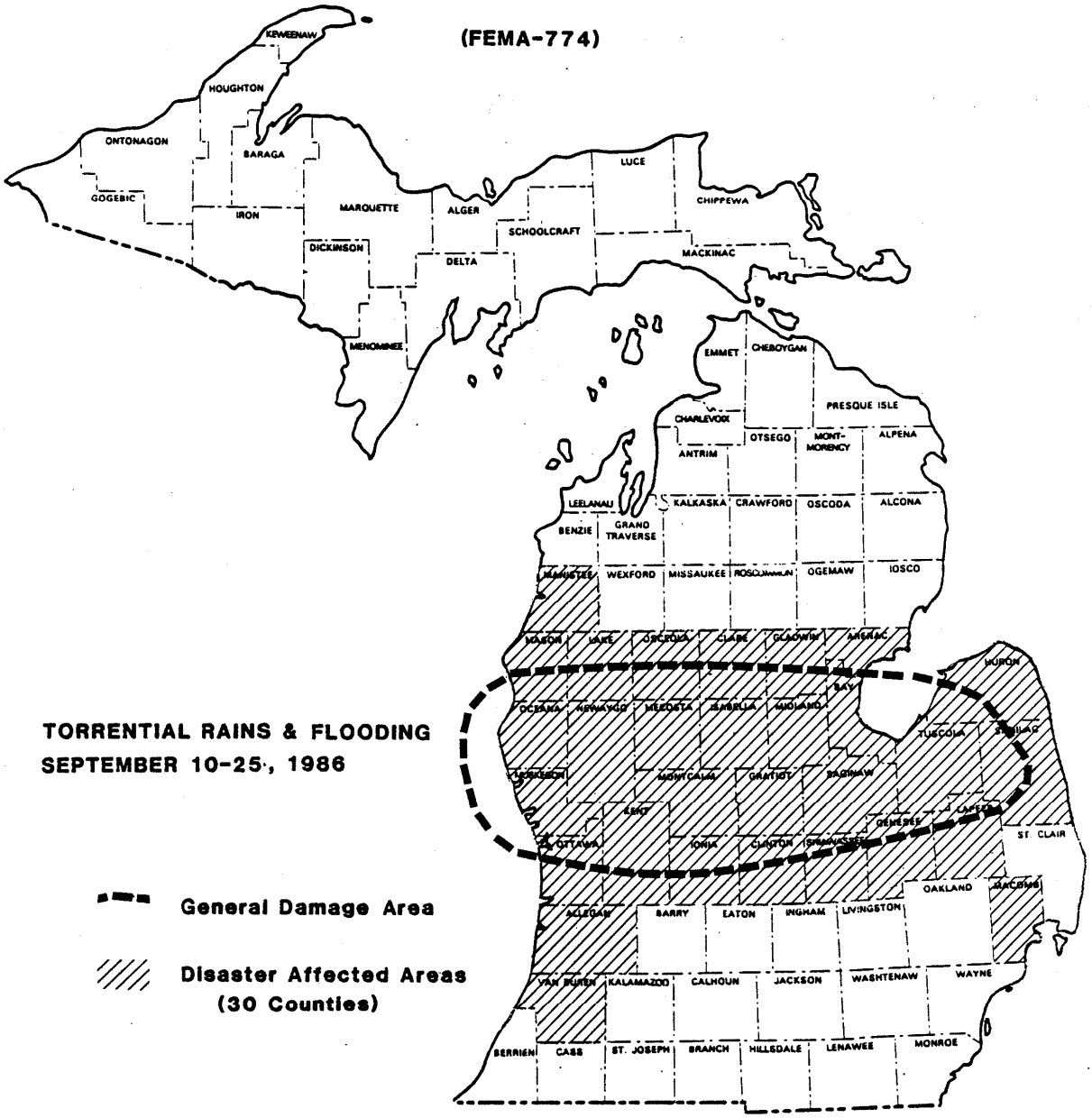
J. Boulton

April 1987

(Note: Reformatted version of scanned copy of original document – August 2004.)

MICHIGAN
Flood Disaster Area Map



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VII. PLAN AUTHENTICATION

I. INTRODUCTION

A. Authorities - This flood hazard mitigation plan has been prepared by the Michigan Department's of Natural Resources and State Police to fulfill the State of Michigan's responsibilities under Section 406 of P.L. 93-288 (Disaster Relief Act of 1974). The Section 406 Plan was in response to the September 18, 1986 Disaster Declaration (FEMA-774-DR-MI) covering the 30 counties of Allegan, Arenac, Bay, Clare, Clinton, Genesee, Gladwin, Gratiot, Huron, Ionia, Isabella, Kent, Lake, Lapeer, Macomb, Manistee, Mason, Mecosta, Midland, Montcalm, Muskegon, Newaygo, Oceana, Osceola, Ottawa, Saginaw, Sanilac, Shiawassee, Tuscola, and Van Buren.

B. Purpose - The purpose of this plan is to outline opportunities to reduce or mitigate the potential for future flood losses in the areas covered by the disaster declaration. Some aspects of the plan go beyond the covered area by pointing out problems that are statewide in nature.

As noted in the Interagency Hazard Mitigation Report, the damage that occurred in many areas was the result of flooding that exceeded the 100-year event. Accordingly, mitigation opportunities were not considered in some cases, since it is not economically feasible to design all facilities for such a rare event. Care should be taken to prevent "over-designing" a facility in response to this disaster.

The focus of this report ranges from local and statewide opportunities to needs at the national level.

C. Scope - The mitigation plan will describe the flooding event, damages caused, flood history, problem identification, existing mitigation measures, and mitigation opportunities. The mitigation opportunities include the opportunities contained in the Interagency Hazard Mitigation Report, with an update on implementation possibilities in addition to opportunities that surfaced after the Interagency Report was published.

II. BACKGROUND

A. Previous flood disasters - The State of Michigan has experienced three federally declared flood disasters in the last five years. The two previous disasters, March 1982 flood in Berrien and Monroe counties with estimated flood damages of $12 million and September 1985 flood in Alcona, Saginaw, Genesee and Lapeer counties with estimated flood damages of $63 million both required the development of State Hazard Mitigation reports. These mitigation reports noted specific measures to respond to the particular flooded areas and statewide measures where it was found that the flooding potential could be reduced by statewide actions. Several actions have been completed and several actions are ongoing. The major cause for not completing tasks is lack of resources, both funding and personnel.

Of significant note are the following successful actions: 1) The City of Niles improved flood fighting procedures after the 1982 flood on the St. Joseph River. The procedure worked in 1985 when flood waters rose to 1982 levels. Flood damages were avoided in 10 blocks of commercial property preventing several hundred thousand dollars worth of damage. 2) Flint Township in Genesee County is proceeding to clear 16 flood prone homes along the Flint River using National Flood Insurance Program's Section 1362 purchase and clearing program. This action was recommended after the 1985 flood. 3) The completion of a generic flood warning/flood fighting evacuation standard operating procedure by the Department of State Police Emergency Management Division. This procedure was used by several communities, including Genesee County, after the 1985 flood to update their standard operation procedure. 4) The drafting of proposed comprehensive flood damage reduction legislation for Michigan. Draft legislation may be introduced this year. 5) Pre-mitigation along our Great Lakes shoreline, offering low interest loans for moving or elevating homes, community grants for shoreline protection and appropriation of state funds to pay the local share for Corps of Engineers advanced measures flood protection projects.

Many other actions are in the process of being evaluated or completed as time permits. Of significant note is the federal agencies efforts in completion of recommended mitigation opportunities. It appears that personnel and funds for mitigation purposes are very limited at the federal level, so much so, that initiation of recommended projects has not been a priority once the required 15 day report is completed.

B. Description of the flood - The flood disaster of September 1986, in central Michigan was the result of extremely heavy rainfall starting on September 10, 1986. The storm system measured approximately 180 miles east to west, and 60 miles north to south, and dumped rainfall amounts ranging between 8 and 14 inches. The 100-year, 24-hour rainfall in Michigan is about 5 inches. Intense rainfall of this magnitude has occurred before in Michigan, however, it has been widely scattered, as a result of locally severe thunderstorms.

In addition to the intense rainfall on September 10-12, central Michigan also received 26 consecutive days of rainfall. Some areas received over 19 inches of rain for the month of September. The continual rainfall amplified the already severe damages and hampered the recovery effort.

On September 24 and 25, 1986, southwestern Michigan was hit with an intense rainstorm that produced 24-hour rainfalls of 4 to 6 inches. This rainfall resulted in Allegan and Van Buren counties being added to the disaster declaration. Following is a listing of monthly and daily rainfall at selected stations affected by the storm.

Rainfall, Inches*

Location	County	1986 Monthly Total	Previous Monthly Record	1986 Greatest Day	Previous Greatest Day Record	Sept. 10-12 Storm
Big Rapids	Mecosta	19.05	11.32	7.64	4.43	13.13
Alma	Gratiot	16.31	8.72	9.33	5.50	10.76
Midland	Midland	18.35	12.76	8.05	4.31	11.78
Mt. Pleasant	Isabella	15.42	10.50	9.35	4.25	10.78
Saginaw	Saginaw	17.48	10.22	7.90	4.58	11.35
Caro	Tuscola	18.16	8.19	7.28	3.20	11.51
Hart	Oceana	11.44	11.61	5.43	4.83	7.69

*From NOAA Climatological Data for Michigan

The record rainfall resulted in record stages on numerous rivers throughout the state. Following is a listing of 1986 peak flows and the estimated 100-year flow prior to the 1986 peak:

Watercourse	Location	1986 Peak (cfs)	100-Year Flood (cfs)*
Maple River	Maple Rapids	7,920	8,880
Flat River	Smyrna	4,700	3,340
Rogue River	Rockford	6,000	4,200
Little Muskegon River	Morley	2,300	1,390
Muskegon River	Newaygo	23,200	14,400
Pere Marquette River	Scottville	6,340	3,660
Cass River	Cass City	12,500	11,000
Cass River	Frankenmuth	22,600	21,400
Chippewa River	Mt. Pleasant	6,660	6,150
Pine River	Alma	5,220	5,040
Pine River	Midland	9,360	6,560
Tittabawassee River	Midland	42,000	47,000
Saginaw River	Saginaw	54,000	68,000

*Not including 1986 flood peak

The frequency of the 1986 flood flows ranged from in excess of a 500-year event on the Pere Marquette to about a 25-year event on the Saginaw River. Only a portion of the Saginaw River basin (6060 square miles received the intense rainfall. As a result, record flood flows did not occur at Saginaw, even though some tributaries to the Saginaw River experienced record stages.

C. Cost of Disaster – The cost of the disaster 774-DR broken down by type was estimated to be:

Private	$137,900,000
Agricultural	$300,000,000
Public Facilities	$ 67,300,000

TOTAL	**$505,200,000**

As of February 1987, disaster funds expended broken down by types:

Public Assistance	$11,900,000
Temporary Housing	$ 4,800,000
Individual and Family Grants	$ 4,300,000
Disaster Unemployment	$ 5,000,000
SBA Home Loans	$26,200,000
SBA Business Loans	$ 5,800,000
TOTAL	**$58,000,000**

D. Description of Previous Events – The September 1986 flood was a widespread event affecting most river basins across central Michigan. The majority of the river basins are rural, with land use ranging from cultivated to forested. Most major floods in these basins occur in March or April, as a result of spring rains and/or snow melt. Occasionally, thunderstorms may cause flooding during the summer or fall. However, the thunderstorms tend to have more impact on watercourses with smaller drainage areas.

The following is a listing of major floods of record for various drainage basins across central Michigan:

Date	Gage Height (feet)	Peak Discharge (cfs)	Rainfall (inches)
Saginaw River at Saginaw (Drainage Area = 6,060 sq mi)			
24-29 March 1904	24.9	68,000	1.5
10-15 September 1986	24.2	54,000	8
17-22 March 1918	23.5	51,700	Trace
Tittabawassee River at Midland (Drainage Area = 2,400 sq mi)			
10-14 September 1986	34.1	42,000	9
24-28 March 1916	29.7	34,800	1.4
17-21 March 1948	29.5	34,000	2.4
Cass River at Vassar (Drainage Area = 710 sq mi)			
10-15 September 1986	24.0	20,000	11
17-21 March 1948	20.8	18,000	2.2
28 March-1 April 1904	19.0	N/A	1.5
Chippewa River at Mt. Pleasant (Drainage Area = 416 sq mi)			
10-13 September 1986	15.6	6,600	11
5-8 March 1946	12.8	4,960	1.0
17-20 March 1948	12.3	4,460	2.0
Pine River at Alma (Drainage Area = 288 sq mi)			
10-13 September 1986	12.8	5,220	11
17-19 March 1948	10.8	4,400	2.0
4-6 February 1938	10.4	4,070	1.5
Muskegon River at Newaygo (Drainage Area = 2,350 sq mi)			
10-12 September 1986	19.6	23,100	10.5
23-25 March 1913	N/A	14,950	N/A
31 May-1 June 1945	13.8	11,600	4.2
Rogue River near Rockford (Drainage Area = 234 sq mi)			
10-13 September 1986	12.0	6,000	12
2-7 March 1976	9.3	3,540	4
28-31 March 1960	8.6	2,080	.6
Pere Marquette River at Scottville (Drainage Area = 681 sq mi)			
10-13 September 1986	8.1	6,340	9.5
26 June-1 July 1969	6.3	2,970	5
2-7 March 1976	6.2	2,940	3.9
Flat River at Smyrna (Drainage Area = 528 sq mi)			
10-13 September 1986	9.0	4,700	10
17-22 April 1967	7.3	3,100	4.8
9-12 April 1965	7.2	3,020	.7
Maple River at Maple Rapids (Drainage Area = 434 sq mi)			
23-26 March 1904	13.8	N/A	2.5
10-13 September 1986	12.3	7,920	8
17-21 March 1948	11.2	6,500	2.3

III. PROBLEM IDENTIFICATION

A. Cause of Damage - The damage that occurred in Central Michigan was the result of record rainfalls that could not be handled by the existing drainage systems. Rivers and streams throughout the disaster area experienced extreme flooding with most of them reaching their highest recorded flood levels. Damage occurred to homes, business, crops and public facilities.

B. Description of the Damage - Throughout the 30 counties, people were evacuated and about 30,000 homes suffered first floor and/or basement damage. Hundreds of millions of dollars of damage was sustained by crops in Mid-Michigan.

About 3,600 miles of roadways were impassable as a result of the failure of 4 primary road bridges and hundreds of secondary road bridges and culverts. The heavy rainfall resulted in 11 dam failures and 19 others threatened with failure.

C. Reason for Damage - The main reason for the damage was the existing drainage systems not being able to handle the runoff from the record rainfalls. This resulted in overland and riverine flooding that inundated homes and business in low lying areas, washed out road crossings, damaged sanitary sewer systems, and caused severe crop damage. It is not economically feasible to try to design highway culverts, storm sewers, or agricultural dikes to handle the rainfall that occurred in 1986, which was far in excess of the 100-year event in many areas.

Within the disaster area there are existing business and residential developments that have received damage from flooding in the past. The majority of such developments have occurred prior to state and local floodplain regulations and have not been adequately elevated or flood proofed. In some instances, even structures constructed according to NFIP regulations were flooded because of the extreme nature of the event. In addition, some structures not within identified flood hazard areas were flooded or suffered basement damage as a result of storm sewer backup.

The failure of highway bridges and culverts resulted from the design capacity of the structure being exceeded. In some cases, high road embankments resulted in extensive back water, failure of the structure, and costly repairs. The more desirable design included low road embankment at the stream crossings that allowed water to flow over the roadway. The resulting erosion of the roadway embankment is a relatively inexpensive failure to repair.

The failure and threatened failure of numerous dams was primarily the result of inadequate spillway capacity. The majority of the dams were constructed without an emergency spillway, or an adequate inspection/maintenance program. The excessive rainfall resulted in the design capacity of the dam being exceeded, causing failure of the dam or intentional breaching of the embankment to save the structure.

The crop losses were the result of several problems. The amount and the intensity of the rainfall exceeded the drainage capacity of the farm drains, which resulted in ponding of water on the crops. In addition, rainfall throughout the month of September kept the fields wet and prevented harvesting. Many acres of farmland in the Saginaw River basin are in the floodplain, and are among the most productive in Michigan. In many instances, private dikes have been constructed in an effort to prevent flood damage. However, typically these dikes are neither designed nor constructed properly and can aggravate the flooding situation.

IV. EXISTING MITIGATION MEASURES

A. Federal - Within the Saginaw River Basin there has been considerable activity pertaining to proposed flood control projects and floodplain management activities. Flood control projects have been active since 1954. The remaining river basins within the disaster area are more rural and activity has been limited to floodplain management activities at the state and local level.

1. A survey report was prepared by the Detroit District, Corps of Engineers in January 1954, which involved a study of the entire Saginaw River Basin. (The major tributaries within the basin include the Tittabawassee, Cass, Pine, Shiawassee, and the Flint Rivers) This report identified several areas where serious flood problems existed and where flood control and drainage improvements would be economically feasible. The recommendation called for flood protection projects to be constructed at Frankenmuth, Vassar, Flint, Corunna, Owosso, Midland and Shiawassee Flats.

2. The Flood Control Project for the City of Frankenmuth was constructed, and significantly reduced the flood damage within the city.

3. A December 1982 Flood Control Project for the City of Vassar was approved, but unfunded. The project consisted of the construction of flood walls and levees, bridge improvements, drainage structures, and the diversion of Moore Drain. The U. S. Army Corps of Engineers indicates that the project would have contained the 1986 flood. The benefit cost ratio for the authorized plan was 1.06. Using current interest rates, the project would not be economically justified.

4. In April 1975, the Corps of Engineers prepared a Flood Control Project Design Memorandum for the City of Midland. The project involved dike and flood wall, construction and enlargement of the Tittabawassee River. The city rejected the structural approach, in favor of a nonstructural project. The January 1977 Flood Control Project Design Memorandum at Midland provided for permanent evacuation, floodplain regulation and recreational development. This particular project was not implemented; however, the city is purchasing flood prone parcels as they become available.

5. The November 1982 Flood Control Project at the Shiawassee Flats proposed construction of new levees, drainage and control structures, channel improvement, relocation of buildings, and raising bridges. The project would have provided 2-5-year protection. Local support was not available for the project.

6. The July 1975 Rogue River Watershed Plan was prepared by the U. S. Department of Agriculture, Soil Conservation Service for the upper portion of the Rogue River in Kent County. The plan involved channel modification, water level control structures, and sediment traps. The project provides protection against flooding up to a ten year frequency event. This project had minimal impact on flood stages and flood damage resulting from the September 1986 flood.

7. The 1960 Misteguay Creek watershed project designed by the U.S. Department of Agriculture, Soil Conservation Service consisted of 3 flood water retarding structures, 43.4 miles of channel work, and 5.7 miles of levees. The project was completed in the 1960's, and has had a very significant effect in the reduction of flood damages in the watershed. As a result of the 1985 and 1986 floods, the Soil Conservation Service has begun to repair and redesign portions of the project.

B. State - A major area of nonstructural flood hazard mitigation is the system of local and state regulations that govern building and rebuilding in the floodplain. Both the local and state provisions serve as continuing flood hazard mitigation tools. They become particularly important during the recovery phase of a flood disaster.

State Regulations Dealing with Floodplain Development

a) The Floodplain Regulatory Authority (P.A. 245 of 1929, as amended by P.A. 167 of 1968) - provides the Michigan Department of Natural Resources with regulatory authority regarding the alteration, occupation or filling of a floodplain.

b) The Subdivision Control Act (P.A. 288 of 1967) - vests in the Michigan Department of Natural Resources (DNR) regulatory authority over proposed subdivisions abutting a watercourse for review and establishment of the 100-year floodplain limits.

c) The Shorelands Protection and Management Act (P.A. 245 of 1970, as amended) - requires a permit from the Department of Natural Resources prior to construction in coastal flood risk areas as designated by the Department. Local units of government can take over administration by adopting a department approved floodplain management ordinance.

d) Wetland Protection Act (P.A. 203 of 1979) - land owners are required to obtain a permit from the Michigan Department of Natural Resources for construction, dredging, draining or the filling of wetlands.

e) The Inland Lakes and Streams Act (1972 P.A. 346, as amended) regulates the dredging, filling, or occupation of bottomland.

f) The Soil Erosion and Sedimentation Control Act (1972 P.A. 347) regulates construction practices to minimize soil erosion.

g) The Condominium Act (1978 P.A. 59, as amended by 1982 P.A. 538 and 1983 P.A. 113) - states that new condominium developments shall not be constructed where it may be reasonably anticipated that the structures will be damaged by flooding.

h) The Governor's Executive Order 1977-4 requires state agencies to take flood hazards into account when planning new facilities, repairing flood damaged buildings, disposing of lands and evaluating land use plans.

i) The Mobile Home Commission Rules (R 125.1602(g) (7) (8)) states; "(7) Mobile homes shall not be placed in a designated floodway, as determined by the Michigan Department of Natural Resources. (8) Mobile homes which are sited within a floodplain shall have installed an anchoring system in compliance with R 125.1605 to R 125.1608. R125.1908 requires that the 100-year floodplain contour be shown on the mobile home park, and that the pads be placed above the 100-year floodplain elevation.

j) The State Construction Code consists of the BOCA Basic/National Building Code/1984 edition with Amendments. Section 1313.0 of that code requires review of "all buildings or structures located in areas prone to flooding" to see that they "shall be flood proofed in accordance with provisions of this section."

C. Local

1. Local Regulations Dealing with Floodplain Development - the communities involved in this disaster declaration have various levels of floodplain management regulations. They vary from none to more stringent than state or federal regulations. Local enforcement of more stringent ordinances than required can result in more restrictive floodplain land use and increased flood loss mitigation. A local governmental agency can, for example, prohibit floodplain development or can add additional elevation requirements. At minimum, officials need to enforce flood hazard provisions of the building code and be aware of and support state and federal floodplain requirements.

The effectiveness of a floodplain management program is very dependent upon the effectiveness of the enforcement (building and zoning inspection) at the local level. If the building inspector or zoning administrator is not aware, or does not enforce the building code pertaining to developments or improvements in the floodplain, flood losses will continue to rise.

Individually, the state or local controls are not as comprehensive as desirable for proper floodplain management; however, when used together, the controls are fairly effective. The local unit of government has authority to enact and enforce comprehensive floodplain management by going beyond the state and National Flood Insurance Program minimum regulations. To do this, local officials must have floodplain management firmly in mind when developing land use plans.

2. Specific Local Mitigation Activities

a) The City of Midland has been purchasing flood prone property with help from a grant by The Herbert H. and Grace A. Dow Foundation. The purchase is made on a voluntary basis and the land is set aside for open-space use.

b) During the 1986 flood, the City of Zilwaukee used a volunteer sandbagging effort to reduce the flood damages from the Saginaw River. The decision to sandbag was based upon the National Weather Service's River Forecast Center flood forecast.

V. RELATIONSHIP BETWEEN EXISTING MEASURES AND DAMAGES

Existing mitigation measures are reducing flood damages. This is evident in Frankenmuth in which the construction of a Corps of Engineers Flood Control Project prevented flood damage during the 1986 flood.

The City of Midland has purchased and removed homes within the floodplain/floodway of' the Tittabawassee River. The purchase is done solely on a voluntary basis, as money becomes available.

Bridgeport Township facilities constructed above the 100-year flood elevation were severely damaged by this flood, which points out the fact that protection to the 100-year flood level is not a complete solution to avoiding damages.

There are also areas in which improvements to mitigation measures could further reduce the damages. The recommendations listed in the following section indicate opportunities for improving existing measures as well as implementing new measures.

VI. IMPLEMENTATION MEASURES

The flooding of September 1986, covered such a wide spread area, it was not possible for the Interagency Hazard Mitigation Team (IHMT) to visit every site to develop its recommendations. In many instances, a recommendation developed for one community or agency would be applicable to others. As a result, recommendations were made which apply statewide. The recommendations are grouped into the following categories.

A. Specific Measures to Respond to 1986 Flood

1. Muskegon River, Newaygo County
2. City of Vassar, Tuscola County
3. Other flood stricken communities

B. State-wide Measures

1. Relocation and Acquisition
2. Warnings/Emergency Plans
3. Dam Safety/Operations
4. Floodplain Management
5. Agriculture
6. Infrastructure
7. State Flood Hazard Mitigation Planning
8. Legislative Needs

The following agency designations are used in the elements.

IHMT	Interagency Hazard Mitigation Team
FEMA	Federal Emergency Management Agency
MDNR	Michigan Department of Natural Resources
SBA	Small Business Administration
SCS	Soil Conservation Service
NWS	National Weather Service
MDA	Michigan Department of Agriculture
MSP-EMD	Michigan State Police Emergency Management Division
USACE	U. S. Army Corps of Engineers
USGS	U. S. Geological Survey
MDOC	Michigan Department of Commerce

A. Specific Measures to Respond to 1986 Flood

1. Work Element: Provide local units of government with technical expertise and encouragement to develop a relocation/acquisition plan for damaged buildings that lie within the floodway of the Muskegon River in Newaygo County. To provide the technical assistance, it is necessary to determine the floodway of the Muskegon River within Ashland, Bridgeton, Brooks, and Garfield Townships. All available options and necessary resources need to be defined for state and local officials to aid in the decision process. Acquired lands should be dedicated to public open space with restrictive covenants prohibiting future redevelopment.

Background: Sixty-four homes were flooded in Garfield Township's Old Woman's Bend and Anderson Flats developments. As many as thirty homes were essentially destroyed. Old Woman's Bend Subdivision has flooded in the past, though not with the magnitude of this event. All of the Old Woman's Bend subdivision lies within the floodway. Redevelopment of these substantially damaged homes could cause serious health and safety problems, may violate State and local codes, and may cause the loss of the availability of Federally subsidized flood insurance within the entire community. Homes not relocated should be elevated above flood levels.

Lead Agency: FEMA (Public Assistance, Individual Family Grant, and Temporary Housing programs), HUD, SBA, MDNR, MSP-EMD, MDOC, and Newaygo County and affected townships (Brooks, Garfield, Bridgeton and Ashland).

Schedule: Garfield Township has applied to the Michigan Department of Commerce for a one million dollar Community Development Block Grant under the Michigan Small Cities Program, to be used for the relocation/acquisition of flood prone structures within the Township. The block grant has been awarded and the project should be completed in September 1987.

The Michigan Department of Natural Resources has prepared a floodplain/floodway analysis for the Muskegon River from Bridgeton to Newaygo. This information defines the floodway limits and establishes the 100-year floodplain elevations. It was determined that the majority of Old Woman's Bend, Anderson Flats and portions of other developments lie within the floodway of the Muskegon River. The information has been provided to FEMA to be used in the preparation of a Flood Insurance Study.

Additional river cross sectional information is needed to extend the study upstream through Devils Hole (Brooks Township) and downstream through Bridgeton Township. This information is tentatively scheduled to be obtained in the summer of 1987 with results available in January 1988.

2. Work Element: Provide technical expertise and encouragement to the City of Vassar officials to define available options for handling the severely flood damaged buildings in the city. The Flood Insurance Study for the City should be revised to reflect current 100-year flood discharge estimates, and to better define the 100-year flood elevation. Structural flood protection projects as well as nonstructural measures, including acquisition, relocation, and floodproofing, should be considered.

In addition to the USACE defining available options, other resources should be identified that could support relocation/acquisition as an alternative to USACE structural/proposals.

Background: The City of Vassar suffered extensive damage during this event. A large portion of the central business district was inundated by eight feet of water for three days. Forty-two homes have been prevented from being reoccupied pending repairs. The sewage treatment plant and power substation were both rendered inoperative during the flood. Vassar has been repetitively flooded, but never to this magnitude.

There exists an approved, but unfunded, USACE protection project for Vassar. The USACE believes that had this project, primarily levees, been in place, it would have contained this flood. This project has been deferred as it fails to meet budget criteria of the current administration.

Lead Agency: FEMA, SBA, City of Vassar, MSP-EMD, MDNR, MDOC and USACE.

Financing: Community Development Block Grant, SBA, NFIP 1362 Program.

Schedule: A task force (MDNR, MDOC, MSP-EMD, FEMA, SBA) met with a committee formed by the City of Vassar, and provided guidance in applying for SBA loans, FEMA 1362 relocation funds and a Community Development Block Grant. The City desires to relocate the downtown business district and residential areas to locations outside of the 100-year floodplain.

The city developed priorities for purchasing homes in the floodway with a Community Development Block Grant and 1362 funds and is encouraging citizens to apply for SBA loans. Initial purchases of homes with Community Development Block Grant funds should be completed by September 1987.

The MDNR is in the process of preparing a revision to the Flood Insurance Study (FIS) for the City, to reflect current

100-year flood discharge estimates. Preliminary results indicate a profile about 2 to 3 feet above the stages shown in the FIS. The revision is scheduled to be submitted to FEMA by July 1987.

3. Work Element: Provide technical expertise and encouragement to flood stricken communities to help define available mitigation projects that could be funded with Community Development Block Grant funds.

Background: The Interagency Hazard Mitigation Team could visit and make mitigation recommendations to only a few of the heavily damaged communities throughout the state. With the publishing of the 15 day report, there remained many mitigation opportunities across the state that had not been addressed.

The Department of Commerce developed an Emergency Community Assistance Fund using $6,000,000 of Community Development Block Grant funds. Application procedures were announced and applications sent to interested communities.

Lead Agency: MDOC, MSP-EMD and MDNR

Financing: Community Development Block Grant, Small Cities Program

Schedule: A review committee from MDOC Office of Grant Management; MSP Emergency Management Division; and MDNR - Flood Hazard Management Program reviewed applications, met with communities to define projects and recommended acceptable projects for funding. Fifteen have been approved to receive funds for projects that include relocation of existing structures, clearing of the floodway, relocation of sanitary sewage facilities, protective diking and elevation of buildings above the 100-year flood level. The communities include: the Cities of Alma, Hart, Newaygo, St. Louis, Vassar, and White Cloud; the Townships of Bangor, Bridgeport, Everett, Garfield, and Midland; the Villages of Elsie, Pentwater, and St. Charles; and the County of Mecosta.

B. Statewide Measures

1. RELOCATION AND ACQUISITION

Average annual losses from flooding in Michigan are estimated to be from 60 to 100 million dollars. These figures point out the tremendous need to provide options to repairing and reoccupying heavily damaged flood prone, structures. Continuing to reestablish these structures is questionable from a standpoint of public safety and public expense.

Work Element: Develop a realistic Federal, State, and/or local program to relocate or flood proof flood damaged structures.

Background: Existing floodprone structures need to be addressed to break the flood-rebuild-flood-rebuild cycle. A recent Federal Emergency Management Agency study suggests that over 200,000 Michigan buildings are prone to flooding. The impetus to remove floodprone structures from the floodplain has to come from the local level. The state and federal government can provide technical support and funding but the decision to clear flood prone structures is primarily local.

Several examples where State and local government have implemented measures to reduce the vulnerability of structures to flooding include: (1) The City of Midland has an ongoing acquisition program for property in flood prone areas. (2) The City of Owosso just completed removing 40 structures from the floodplain as part of a redevelopment project. (3) In 1986, the state had a loan subsidy program for relocation or floodproofing along Lakes Michigan, Huron, St. Clair, Erie, and Superior. (4) In 1986, the state also implemented a shoreline protection program which made grants of up to $30,000 available to Great Lakes jurisdictions for shoreline protection or hazard mitigation measures. These programs should be reviewed and evaluated as models to aid in the development of additional programs.

Lead Agency: MDNR, MSP-EMD, MDOC, City of Midland, and City of Owosso.

Financing: State and local appropriation corporate match programs, USACE, FEMA, and Community Development Block Grant and Land and Water Conservation programs.

Schedule: The Michigan Department of Commerce has made about 6 million dollars of Community Development

Block Grant funds available to communities for flood hazard mitigation purposes to aid in recovery from the September 1986 flood. The block grant is based upon urgent need and is limited to one million dollars per community. The program promises to be very effective and was the first major effort on post flood mitigation in the State of Michigan. Continuation of an Emergency Community Assistance Fund in a post disaster context is a very important part of breaking the flood-rebuild cycle.

The state needs to continue looking at financial incentives to move or elevate structures in hazard areas in a pre-flood disaster format. A version of the low interest loan program offered by the state in 1986 should be considered on a statewide basis and as a permanent program. Draft legislation is presently being considered.

2. WARNINGS/EMERGENCY PLANS

Many of the problems encountered by the IHMT were a result of a lack of information, failure to coordinate information, or the misunderstanding of information. The recommendations in the following section are aimed at eliminating similar future incidents.

a) Work Element: Develop and test river basin warning/communication networks, as monies become available.

Background: Throughout this event, coordination of all available information was lacking. Local communities were unaware of the role they could play in data collection for River Forecast Centers. The existing gage at Midland overturned and provided NWS with •inaccurate data. The City of Midland was forced to manually measure flood heights and inform NWS. Without accurate data, the prediction capabilities of the Forecast Center were severely limited, which led to media confusion or inaction in dissemination of information.

An improved system should be developed which will require: (1) a network of rainfall measuring devices, (2) additional river stage gages to be placed upstream of vulnerable communities; (3) a network of volunteers to read the rain gages and river gages and report the results to a central location, and (4) a central collection point to provide the NWS River Forecast Center with data.

It is recommended that all Emergency Services Directors and media both have access to the National Weather Service Wire and also monitor the National Oceanic and Atmospheric Administration Weather Radio.

Lead Agency: NWS, USGS, MDNR, MSP-EMD, county emergency coordinators, local law enforcement agencies, dam owners, volunteers, and radio/television stations.

Financing: USGS, USACE, and local governments; mostly existing budgets.

Schedule: There are very few sources of funding to develop River Basin Warning/Communication networks. The NWS is planning some new forecast points on the Flint River Basin, but volunteers will be needed to monitor these gages. Funds are not available for gages accessed by telephone (Telemark). USGS installs gages for the NWS, but has no funding of its own to independently place new gages.

A combination of private and FEMA funds were utilized to develop a flood forecasting model for the Grand River Basin. The model incorporates input from Telemark Gaging Stations and dam operators to forecast flood stages in the basin. Federal, State, or private funds will be needed to develop similar models for other major rivers in the state.

The City of Midland is currently evaluating several different types of gages to determine what equipment best fits their needs. Once the review process is completed, they plan to identify a funding source for implementation.

b) Work Element: Review and update local Emergency Operation Plans (EOP).

Background: Current EOPs should be reviewed in light of the recent disaster. Nationally, coordination of reliable information appears to be one of the major short falls in emergency operations. Michigan EOPs should be reviewed to insure a reliable coordination system for proper emergency response is delineated. The EOPs should include role and responsibility assignments to eliminate confusion. Emphasis should be placed on direction and control, warning, communication, assessment and public information annexes. The EOPs should address multi-jurisdictional and

multi-sector planning and coordination, identify an official spokesperson for dissemination of information to media outlets, and include an after-action review. The plan should be reviewed annually by those who use it for changes in conditions and personnel to ensure proper delineation of roles and responsibilities. The MSP-EMD has developed guidelines and a format for local government use and is capable of providing necessary technical assistance.

Lead Agency: MSP-EMD, MDNR, and FEMA.

Financing: Existing programs.

Schedule: The Planning Section of MSP-EMD has developed a guidance workbook for jurisdictions with Emergency Management Programs, to follow in developing an Emergency Operations Plan (EOP). The workbook provides an outline format, asks questions and includes sample language which meets minimum criteria for a good EOP. The suggested format includes a basic plan and the following annexes: Direction and control, warning, communications, assessment, public information, law enforcement, fire services, public works, health services, and human services.

At the request of a local jurisdiction and as existing priorities allow, the Planning Section provides technical plan writing assistance to the entire State. In 1986, 16 local jurisdictions were assisted in revising and updating their EOP. Ten jurisdictions in the disaster area were assisted: counties of Genesee, Isabella, Kent, Midland, Muskegon, and Saginaw; and the cities of Flint, Bay City, Midland, and Mt. Pleasant. In addition to the Planning Section's efforts, the Training Section conducts a week long Emergency Planning Course several times each year to further assist local jurisdictions who are interested in improving their plans. FEMA requires local EOPs to be reviewed and updated every three years and MSP-EMD requires local EOPs to be revised every two years.

The MDNR is under contract with FEMA to develop a manual discussing and illustrating flood fighting techniques and pre-flood mitigation activities. The manual will be used in two pilot communities to develop a community wide pre-flood mitigation plan. The manual will be distributed statewide to Great Lakes communities and National Flood Insurance Program (NFIP) communities.

3. DAM SAFETY/OPERATIONS

During the 1986 flood, there were eleven dams which either failed due to inadequate spillway capacity or were breached in order to control the release of water to save the threatened structure. This number suggests that investigations and improvements to Michigan's regulation of dams is necessary. Additionally, there needs to be an improvement in the coordination of information concerning water released or passed through dams.

a) Work Element: Adopt State legislation that effectively addresses dam safety issues, including periodic inspections, maintenance standards, emergency action plans, and impoundment regulations.

Background: While inspecting damage representative of the numerous breaches/failures, many questions concerning normal maintenance and operations procedures arose. While the State of Michigan inspects dams during construction, there is currently no ongoing inspection/maintenance program, no requirement for developing emergency action plans for high water situations, as well as failure, and no regulation of impounded water levels.

The MDNR sponsored dam safety workshops across the State in early 1986 and has developed draft legislation to address these issues. This legislation needs to be sponsored and introduced to the 1987 legislative session for adoption.

Lead Agency: MDNR, MSP-EMD, Governor's Office and FEMA.

Financing: None required for adoption; legislative appropriation for program.

Schedule: The draft legislation has been prepared and is planned to be introduced in the 1987 legislative session.

b) Work Element: Expand emergency action plans for dams to include notification and warning procedures for the occasional unusual increase in flow release.

Background: Several communities in this disaster related that actions of upstream dam owners were not well understood by localities that were subject to the impact of increased flow releases. This increased the problems of predicting local flood stage levels. Current dam emergency action plans contain only notification and warning procedures for imminent failure conditions. These plans should be expanded to include such actions for the more frequent event of unusual increased flow releases. These plans should then be coordinated with the NWS, local emergency planners, and law enforcement officials. These requirements should be included in the proposed legislation discussed in Work Element 3a and the regional warning systems discussed in Work Element 2a. The implications for safety are significant if not undertaken.

Lead Agency: MDNR, MSP-EMD, Public Service Commission, appropriate power companies, Federal Energy Regulatory Commission, FEMA, NWS, USGS, USACE (in advising capacity), and local governments.

Financing: Legislative appropriation for proposed dam safety program.

Schedule: Upon adoption, the proposed dam safety legislation would require dam owners to prepare and keep current emergency action plans. These plans address actions to be taken prior to and/or following an impending or actual sudden release of water.

4. FLOODPLAIN MANAGEMENT

As is often the case, information is lacking pertaining to the wise use of floodplains and coastal flood zones, the availability and coverage of Federal flood insurance, the implications and implementation of local floodplain management ordinances, and the use of maps, where available. These recommendations are offered in order to improve the awareness of available information and programs.

a) Work Element: Increase public awareness of the NFIP.

Background: In many instances, local officials, insurance agents, and community residents were unaware or misinformed about the National Flood Insurance Program (NFIP). Workshops should be held to describe the NFIP, including eligibility requirements and availability of flood insurance, and the existence of flood insurance maps and their interpretation. For insurance agents, the existing program needs to be reviewed and updated to better inform insurance agents about the NFIP. Flood insurance questions should be added to insurance agent qualification tests.

A program should also be developed to review and monitor Federally regulated lenders to ensure that flood insurance is purchased and maintained for structures within identified floodprone properties.

Lead Agency: FEMA, MDNR, MSP-EMD, and the banking industry.

Financing: FEMA and MDNR.

Schedule: The MDNR has scheduled six floodplain management informational meetings throughout the state for late April and early May 1987. It is hoped that these meetings-will initiate the organization of a State Floodplain Manager's Association. This organization could be a major step in increasing local awareness. The MDNR has also met with the Michigan Insurance Agents Association to discuss the problems, and to increase awareness of the program. The contact should be made on a regular basis.

At the request of MSP-EMD, the Department of Licensing and Regulation will add several NFIP questions to its licensing examination for insurance agents. This should increase agents' level of knowledge and decrease the number of incidents where residents are improperly advised that they can not purchase flood insurance.

The Michigan Department of Commerce's Financial Institution Bureau (FIB) regulates State chartered institutions and requires each institution to have floodplain maps for its geographical lending area. The FIB randomly audits institutions for compliance with NFIP requirements.

The MSP-EMD hosted a FEMA teleconference on flood insurance issues for insurance agents at its training academy. Even though the teleconference was promoted statewide, attendance was low.

b) Work Element: Map areas susceptible to flooding and include best available elevation data on existing floodplain maps.

Background: Unmapped communities that experienced significant damage from this flood need to be mapped. Even though this disaster exceeded the 100-year flood in many places, determining floodprone areas will be helpful for responding to future flooding events.

Current Flood Insurance Rate Maps (FIRM) developed from Flood Hazard Boundary Maps (FHBM) do not contain flood elevation information which-would be helpful to a community for floodplain management. In the case of this event, it would have helped identify areas susceptible to flooding. A public review process needs to be reintroduced so that when best available data, including elevations, is provided to FEMA it is included on maps.

Lead Agency: FEMA, MDNR, MSP-EMD, SCS USAGE, and USGS.

Financing: FEMA and MDNR.

Schedule: By February 1988, communities within the disaster area will be contacted to determine the need for floodplain maps, and to check existing floodplain maps. For those communities expressing the need for a map or changes to existing maps, the MDNR will provide assistance.

There is still a need to include best available data on Flood Hazard Boundary Maps and FIRMs, which will require a procedural change at the Federal level.

c) Work Element: The State of Michigan should sponsor an annual "Flood Awareness Week".

Background: The Michigan Department of State Police, Emergency Services Division, has established tornado and winter storm awareness weeks. The events of this disaster indicate the need for a statewide public education campaign for floods. This program should include wide distribution of maps identifying those areas susceptible to flooding.

Lead Agency: MSP-EMD and NWS.

Financing: Existing budget.

Schedule: The MSP-EMD is planning to conduct a spring Flood Awareness Week during the month of May with an emphasis on flood awareness and safety. This will include a Governors' proclamation, and substantial media support is planned. Flood safety pamphlets, posters, and articles are going to be widely distributed to heighten the public awareness of flood safety and mitigation measures.

d) Work Element: Increase awareness of hazard provisions in building code standards, ordinances, and procedures with local elected officials, building code officials, and floodplain residents.

Background: As Interagency Teams have identified nationwide, and almost continually, lack of enforcement of existing codes and regulations often leads to a significantly greater exposure to flood hazards. In Michigan, awareness of the NFIP minimum requirements and building code requirements needs to be strengthened. Confusion and lack of knowledge of floodplain elevations, floodway designations, and procedures necessary to enforce code requirements (e.g., substantial improvements) is inhibiting loss reduction mechanisms in some flood damaged areas. Among the suggestions put forth toward improving enforcement were:

- evaluate resource requirements for NFIP enforcement.
- expand local building inspector training awareness programs.
- develop procedures and definitions to clarify the enforcement of substantial improvement requirements.
- propose legislation to require identification of floodprone parcels on title abstracts (public disclosure).

Lead Agency: FEMA-Federal Insurance Administration, MDNR, MSP-EMD, Michigan Department of Labor-Construction Code Division, and Code Officials Association.

Financing: Operating budgets.

Schedule: The MDNR is continuing to provide training to local officials and building inspectors to increase awareness of floodplain management. Under contract with FEMA, the following activities will be undertaken during 1987: MDNR will provide three five-hour workshops covering the NFIP requirements and administration, Building Code requirements and Community Program requirements. These workshops should contact between 60 to 100 communities.

The MDNR will be developing four newsletters to be mailed to flood prone communities in Michigan, counties, townships, drain commissioners, regional planning agencies and citizens. The newsletters will provide a continual flow of information on the NFIP which is necessary to maintain community awareness.

The MDNR will conduct 14 community visits to evaluate NFIP compliance and to review requirements with local officials.

5. AGRICULTURE

Agriculture is an appropriate use of the floodplain; however, significant losses frequently occur which can be reduced. This event in Michigan is no different except that the cumulative losses are staggering: about $300 million. Continual, excessive rainfall saturated the ground resulting in the occurrence of standing water in areas miles from identified floodplains. Crops, ready for harvest, were not accessible and rotted in the fields. Farmers, already battling a difficult economic environment, were left with loans from spring planting with no yield to balance their debt. This may be the last financial catastrophe many can endure. Many of the farmers in the declared counties are expected to declare bankruptcy.

As a follow up to an Interagency Hazard Mitigation Team Report in South Dakota (FEMA-717-DR-SD, June 1984), a state by state investigation was made of existing programs to reduce agricultural farm losses. While some measures can be taken (crop selection, storage sites, and insurance) to reduce losses from low magnitude, frequent events, few measures would have been effective during the 1986 flood.

The following recommendations were developed in hopes of reducing future agricultural losses from lesser events.

a) Work Element: The State of Michigan should establish design, construction, and maintenance guidelines for dikes and levees protecting agricultural land.

Background: The Team visited several sites where agricultural levees failed. It appeared that privately owned dikes and levees were improperly located and poorly designed, constructed,' and maintained. While designed to protect from lesser magnitude floods, the Team noticed that many *may* have failed in any event. Guidelines developed should include the following considerations: foundation, structural, embankment, hydraulics and hydrology, interior drainage, storm design frequency, construction inspection, operations, and maintenance with special attention to trees and brush removal.

Lead Agency: MDNR and Michigan Department of Agriculture (MDA) with technical assistance from USACE and SCS.

Financing: Legislature.

Schedule: A schedule and procedure for accomplishing this work element has not been developed. It is still believed to be desirable and will be followed up as schedules permit.

b) Work Element: Review the programs available for providing floodproofing technical assistance in non-project areas for farmsteads located in the 100-year floodplain (e.g., ring dikes and elevated structures).

Background: Not only were there extensive crop losses throughout the declared disaster area, over 1,200 farm houses and other structures were flooded. The Hazard Mitigation Team felt that a review of existing programs might identify additional financial assistance. Policies might be changed where necessary, and increased education of program delivery agencies and local participation could lead to the availability of greater protection.

Lead Agency: USDA, FEMA (on national level), Agricultural Stabilization and Conservation Service (ASCS), Farmers Home Administration (FmHA), SCS, MDA, and MDNR.

Financing: To be determined.

Schedule: The MDNR has been working with the Flint River Dike Committee to develop a dike design that will provide protection to crops, while maintaining the flow carrying capacity of the river. A dike configuration has been developed; however, funding has not been obtained for construction.

c) Work Element: Review existing programs to revise or redirect ongoing assistance efforts to adequately provide disaster coverage to the farm community and to incorporate mitigation measures.

Background: The Team felt that existing emergency programs do not adequately assist farmers during major disaster declarations, and that they do not address mitigation measures such as protection or loss reduction.

Lead Agency: USDA, extension services, Farm Bureau, National Milk Producers Association, and National Farm Organization.

Financing: None required.

Schedule: The lead agencies for this work element are Federal/National Organizations, but Michigan has done several programmatic things to assist farmers. In response to criticism that many farmers were already deeply in debt and did not need another Small Business Administration (SBA) Loan, the Governor and Legislature established an interest free loan program for farmers who suffered serious crop losses. A total of $100 million is being made available through State Chartered financial institutions.

At the request of the Governor and Michigan's congressional contingent, the eligibility criteria for disaster unemployment benefits were reinterpreted to qualify 5,800 farmers for assistance ranging from $54 to $197 per week based on previous year earnings.

6. INFRASTRUCTURE

The intense rainfall and record flood stages resulted in many sewer systems being over-loaded, and many river crossing failures. This section addresses the protection of sewage treatment facilities, enforcement of existing codes, and a review of design standards.

a) Work Element: Create a multi-disciplinary task force to evaluate flood damage to and caused by the failure of sewage handling systems.

Background: Throughout the disaster area, flooding caused damage to sewage handling systems, which in turn, caused additional damages. This task force should review existing guidelines and revise/develop new ones, as necessary. These should address, at a minimum, the following functional areas:

- auxiliary power for lift stations and treatment facilities.
- site locations and related floodproofing requirements.
- adequacy/necessity of storage/holding basins and related design criteria.
- minimizing infiltration and/or inflow, including separation of storm water and sanitary systems, prohibiting footing and roof drains emptying into sanitary systems, and identifying building code changes where appropriate.
- criteria for determining optimum level of floodproofing/protection in relation to storm frequency/cost effectiveness.
- maintenance, operations, and emergency plans to minimize flood damage.
- post-flood recovery operations plans and policies.

Lead Agency: MDNR, MSP-EMD, Michigan Public Health, EPA, EDA, FEMA, and USACE.

Financing: Initially within existing budgets.

Schedule: The Surface Water Quality Division (SWQD) of the MNDR is in the process of reviewing the recommendations developed by the Flood Hazard Mitigation Team. The City of Vassar's new sewage treatment facility will be relocated outside of the 100-year floodway. The proposed new facility for the City of Newaygo will be located outside of the floodplain.

b) Work Element: Create a task force to evaluate the hydraulic design of roads, bridges and culverts.

Background: In many instances, it was noted that roadway overtopping prevented the failure of the bridge/culvert while others with high road fills were destroyed. The design of the facility should achieve a balance between cost, and the needs, risks, and hazards associated with the site.

Lead Agency: FHWA, MDOT, MDNR, County Road Commission.

Schedule: The MDOT and MDNR will be reviewing the causes of failure for many of the stream crossings. A result of the review may be a revision to the design standards for bridges and culverts.

7. STATE HAZARD MITIGATION PLANNING

As a condition for receiving future Federal disaster assistance, States are required to develop and implement a hazard mitigation plan for those areas where grants and loans are made available.

This plan and the 406 Plan developed after last year's Presidential disaster declaration for Flint and the surrounding area (FEMA-744-DR-MI), were developed to aggressively address problems which created the need for federal assistance. However, to address ongoing and changing problems, the state needs to continually review hazard mitigation opportunities.

a) Work Element: Create a State Hazard Mitigation Team with representation from *key* State agencies.

Background: An Interagency Agreement between 12 Federal agencies requires that a hazard mitigation report be developed following Presidential declarations of a major disaster area that are a result of flooding. These interagency team reports, which emphasize nonstructural loss reduction techniques, have been very successful; but the approach requires the participation and coordination of many disciplines.

Since the statutes and regulations that directly or indirectly impact the State's ability to protect the public health, safety, and general welfare from natural and technological hazards are distributed among the various State agencies, a team needs to be created to identify and coordinate existing activities and programs, and to develop a strategy that will continue to reduce Michigan's vulnerability to damages from flooding and other hazards. Other States have initiated State Hazard Mitigation Teams by Executive Order. This has allowed for effective mitigation measures on a continual basis, not just following Presidential disaster declarations.

A State Team strategy would identify and minimize funding of activities in hazard areas and assist in reducing the exposure of State investments to hazards.

Lead Agency: MSP-EMD, MDNR, and Governor's Office.

Financing: None required.

Schedule: Governor James Blanchard has supported the concept of a State Hazard Mitigation Team and will sign an Executive Order to formally create the team. Therefore, the MSP-EMD, in cooperation with the MDNR, will host a training session for all State Department Emergency Coordinators to introduce and explain the concepts of a State Hazard Mitigation Team. The seminar will train departmental coordinators to look for mitigation opportunities that their departments may assist with during their normal regulatory functions. A questionnaire will be distributed to each department which once completed will identify the department's role and capability to impact mitigation issues. The departments which have key mitigation roles will be invited to form a State Mitigation Team and assist

in the development of a Generic Mitigation Plan for all categories of mitigation hazards.

Completion of this work element is projected to take 12-18 months. A tentative schedule is offered below:

DRAFT - GENERIC HAZARD MITIGATION - DRAFT

A. Develop Executive Order (30 days)
- Obtain Governor's signature

B. Hazard Analysis (30 days)
- Review existing document

C. State Capability Assessment (90 days)
- State Department Coordinators meeting/training

Questionnaire and response

D. Identification of Key State Agencies (30 days)
- Select hazard mitigation team

E. Develop Draft of Mitigation Plan (180 days)
- Assign portions of plan to team members
- Meet regularly to monitor progress and critique
- Submit draft 'to state agencies, FEMA, Governor, and key local representatives

F. Review and Publish Plan (90 days)

G. Review Plan Annually/or After Next Disaster

b) Work Element: MSP-EMD should reprioritize their training and education needs to include the training of State agency personnel identified to serve on the State Hazard Mitigation Team proposed in Work Element 7A.

Background: FEMA has just completed the development of a training course specifically designed for State hazard mitigation officers to train members of State hazard mitigation teams in state of the art concepts and techniques in planning and implementing hazard reduction policies. If MSP-EMD agrees to readjust their training and education program for by offering to sponsor this course, FEMA Region V can provide the technical and financial resources necessary.

Lead Agency: MSP-EMD and FEMA.

Financing: Existing Training and Education budget.

Schedule: The MSP-EMD training schedule for 1987 was published in the fall of 1986. At this late date, it is not possible to reschedule the courses to include flood hazard mitigation training.

On March 9-11, 1987, MSP-EMP and MDNR staff attended FEMA Region V's pilot presentation of the mitigation training course to evaluate its appropriateness for Michigan and found it to be an excellent training tool.

If FEMA approves this course in Michigan's Comprehensive Cooperative Agreement for FY88, the course will be included on MSP-EMD FY88 training schedule.

8. LEGISLATIVE NEEDS

a) Work Element: The Michigan legislature should adopt the drafted legislation, entitled "Flood Damage Reduction Act".

Background: This legislation was presented and discussed in the 406 Plan (pages 17-18 and Attachment 1) developed following FEMA-744-DR-MI). This legislation should be reviewed in light of the current disaster, updated where necessary, and brought to the upcoming session of the legislature.

Lead Agency: MNR, MSP-EMD, and Governor's Office.

Financing: None required for adoption; legislative appropriation for programs.

Schedule: The draft legislation was reviewed by MDNR, modified slightly to address needs that became apparent from the September 1986 flood and sent to legislature for adoption. A formal sponsor of this:' legislation will be sought.

b) Work Element: The State of Michigan should review existing legislation and regulations addressing storage of hazardous materials in floodprone areas for adequacy and/or enforcement.

Background: Field investigations indicate containers of hazardous materials (polychlorinated biphenyls - PCBs) were floating in the Tittabawassee and Saginaw Rivers. In Garfield Township, Newaygo County, inadequately secured containers caused the loss of at least 30 propane/LPG tanks. As a result, these containers were floated from their storage sites and carried downstream by flood currents, posing a health and fire hazard. These types of hazard have become increasingly frequent nationwide.

Lead Agency: MDNR, MSP-Fire Marshal, and EPA.

Financing: None.

Schedule: In response to the Superfund Amendments and Reauthorization Act of 1986 (SARA) (PL99-499), Governor James J. Blanchard has established an Emergency Planning and Community Right to Know Commission and has designated the Director of the Department of Natural Resources as Chairman of the Commission. The Commission's duties include responsibility for monitoring the development of local hazardous materials response plans required by the Title III provisions of SARA. Those plans may address the safe storage of hazardous material and at least partially resolve this issue for facilities which are subject to SARA requirements.

Michigan's administrative rules (1984) for Liquefied Petroleum Gases (LPG) requires containers to be securely anchored (3-2.2.5 (g)). The administrative rules for storage of flammable and combustible liquids (1983) also require tanks to be securely anchored (2-5.6.1). The MSP Fire Marshal and Michigan Department of Natural Resources do not have adequate inspection staffs to properly enforce those regulations. Local Building Inspectors or Fire Department Inspectors should place a greater emphasis on enforcement of this area.

VII. PLAN AUTHENTICATION

A. This State Flood Hazard Mitigation Plan has been developed as a result of the Presidentially Declared Disaster, FEMA-774-DR-MI, in accordance with Public Law 93-288, Section 406 and the Federal/State agreements for the disaster.

The purpose of the plan is to outline opportunities to reduce or mitigate the potential for future losses in the disaster area and elsewhere in the state. The plan has been reviewed by each state agency which has assumed roles as lead agencies in implementing this plan.

The Commander of the Emergency Management Division, Department of State Police, is assigned the role of plan coordinator and will be responsible for the follow up to assure implementation where possible.

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APPENDIX G

FEMA Review Sheet for State Hazard Mitigation Plans

State Review Sheet for Local Hazard Mitigation Plans

NOTE: The State Review Sheet is used here because it contains a few additional elements that are not present on the FEMA "Crosswalk" review sheet for local hazard mitigation plans.

Instructions for Using the Plan Review Crosswalk for Review of Standard State Hazard Mitigation Plans

Attached is a Plan Review Crosswalk based on the ***Multi-Hazard Mitigation Planning Guidance Under the Disaster Mitigation Act of 2000***, published by FEMA, with revisions dated November 2006. This Plan Review Crosswalk is consistent with the *Disaster Mitigation Act of 2000* (P.L. 106-390), enacted October 30, 2000 and *44 CFR Part 201 – Mitigation Planning, Interim Final Rule* (the Rule), published February 26, 2002.

SCORING SYSTEM

N – Needs Improvement: The plan does not meet the minimum for the requirement. Reviewer's comments must be provided.

S – Satisfactory: The plan meets the minimum for the requirement. Reviewer's comments are encouraged, but not required.

Each requirement includes separate elements. All elements of a requirement must be rated "Satisfactory" in order for the requirement to be fulfilled and receive a summary score of "Satisfactory." A "Needs Improvement" score on elements shaded in gray (recommended but not required) will not preclude the plan from passing.

Optional matrices for assisting in the review of sections on profiling hazards and assessing vulnerability are found at the end of the Plan Review Crosswalk.

The example below illustrates how to fill in the Plan Review Crosswalk.

Example

Assessing Vulnerability by Jurisdiction

Requirement §201.4(c)(2)(ii): *[The State risk assessment **shall** include an] overview and analysis of the State's vulnerability to the hazards described in this paragraph (c)(2), based on estimates provided in local risk assessments … . The State **shall** describe vulnerability in terms of the jurisdictions most threatened by the identified hazards, and most vulnerable to damage and loss associated with hazard event.*

Element	Location in the Plan (section or annex and page #)	Reviewer's Comments	SCORE N	SCORE S
A. Does the plan describe the State's vulnerability based on information from the local risk assessments?	Section III, pp. 12-28	The plan includes a description of local vulnerable structures. The plan presented a vulnerability summary by regions in the state. This information was collected from the approved plans on file.		✓
B. Does the plan present information on those jurisdictions that face the most risk?	Section III, pp. 30-36	The vulnerability description did not indicate which jurisdictions were the most vulnerable. **Required Revisions:** • Use the information provided in the summaries to determine which jurisdictions are most threatened by the identified hazards. • Identify which jurisdictions have suffered or are likely to suffer the most losses. • If data are not readily available, note these data limitations in the plan. Include actions in the mitigation strategy to obtain these data for the plan update.	✓	
		SUMMARY SCORE	✓	

Standard State Hazard Mitigation Plan Review and Approval Status

State Point of Contact:	**Address:**
Title:	
Agency:	
Phone Number:	**E-Mail:**

FEMA Reviewer:	**Title:**	**Date:**
Date Received in FEMA Region [Insert #]		
Plan Not Approved		
Plan Approved		
Date Approved		

State: Date of Plan:

STANDARD STATE HAZARD MITIGATION PLAN SUMMARY CROSSWALK

The plan cannot be approved if the plan has not been formally adopted.

Each requirement includes separate elements. All elements of the requirement must be rated "Satisfactory" in order for the requirement to be fulfilled and receive a score of "Satisfactory." Elements of each requirement are listed on the following pages of the Plan Review Crosswalk. A "Needs Improvement" score on elements shaded in gray (recommended but not required) will not preclude the plan from passing. Reviewer's comments must be provided for requirements receiving a **"Needs Improvement"** score.

SCORING SYSTEM

Please check one of the following for each requirement.

N – Needs Improvement: The plan does not meet the minimum for the requirement. Reviewer's comments must be provided.

S – Satisfactory: The plan meets the minimum for the requirement. Reviewer's comments are encouraged, but not required.

Prerequisite	**NOT MET**	**MET**
Adoption by the State: §201.4(c)(6) and §201.4(c)(7)		

Planning Process	**N**	**S**
Documentation of the Planning Process: §201.4(c)(1)		
Coordination Among Agencies: §201.4(b)		
Program Integration: §201.4(b)		

Risk Assessment	**N**	**S**
Identifying Hazards: §201.4(c)(2)(i)		
Profiling Hazards: §201.4(c)(2)(i)		
Assessing Vulnerability by Jurisdiction: §201.4(c)(2)(ii)		
Assessing Vulnerability of State Facilities: §201.4(c)(2)(ii)		
Estimating Potential Losses by Jurisdiction: §201.4(c)(2)(iii)		
Estimating Potential Losses of State Facilities: §201.4(c)(2)(iii)		

Mitigation Strategy	**N**	**S**
Hazard Mitigation Goals: §201.4(c)(3)(i)		
State Capability Assessment: §201.4(c)(3)(ii)		
Local Capability Assessment: §201.4(c)(3)(ii)		
Mitigation Actions: §201.4(c)(3)(iii)		
Funding Sources: §201.4(c)(3)(iv)		

Coordination of Local Mitigation Planning	**N**	**S**
Local Funding and Technical Assistance: §201.4(c)(4)(i)		
Local Plan Integration: §201.4(c)(4)(ii)		
Prioritizing Local Assistance: §201.4(c)(4)(iii)		

Severe Repetitive Loss Mitigation Strategy
(only required for 90/10 under FMA & SRL)

	N	**S**
Repetitive Loss Mitigation Strategy: §201.4(c)(3)(v)		
Coordination with Repetitive Loss Jurisdictions §201.4(c)(3)(v)		

Plan Maintenance Process	**N**	**S**
Monitoring, Evaluating, and Updating the Plan: §201.4(c)(5)(i)		
Monitoring Progress of Mitigation Activities: §201.4(c)(5)(ii) and (iii)		

STANDARD STATE HAZARD MITIGATION PLAN APPROVAL STATUS

PLAN NOT APPROVED	
PLAN APPROVED	

See Reviewer's Comments

PREREQUISITE

Adoption by the State

Requirement §201.4(c)(6): *The plan **must** be formally adopted by the State prior to submittal to [FEMA] for final review and approval.*

Requirement §201.4(c)(7): *The plan **must** include assurances that the State will comply with all applicable Federal statutes and regulations in effect with respect to the periods for which it receives grant funding, in compliance with 44 CFR 13.11(c). The State will amend its plan whenever necessary to reflect changes in State or Federal laws and statutes as required in 44 CFR 13.11(d).*

Element	Location in the Plan (section or annex and page #)	Reviewer's Comments	SCORE NOT MET	SCORE MET
A. Has the State formally adopted the **new or updated** plan?				
B. Does the plan provide assurances that the State will **continue to** comply with all applicable Federal statutes and regulations during the periods for which it receives grant funding, in compliance with 44 CFR 13.11(c), and will amend its plan whenever necessary to reflect changes in State or Federal laws and statutes as required in 44 CFR 13.11(d)?				
		SUMMARY SCORE		

PLANNING PROCESS: *§201.4(b): An effective planning process is essential in developing and maintaining a good plan.*

Documentation of the Planning Process

Requirement §201.4(c)(1): *[The State plan **must** include a] description of the planning process used to develop the plan, including how it was prepared, who was involved in the process, and how other agencies participated.*

Element	Location in the Plan (section or annex and page #)	Reviewer's Comments	SCORE N	SCORE S
A. Does the plan provide a narrative description of how the **new or updated** plan was prepared?				
B. Does the **new or updated** plan indicate who was involved in the **current** planning process?				
C. Does the **new or updated** plan indicate how other agencies participated in the **current** planning process?				
D. Does the updated plan document how the planning team reviewed and analyzed each section of the plan?				
E. Does the updated plan indicate for each section whether or not it was revised as part of the update process?				
		SUMMARY SCORE		

Coordination Among Agencies

Requirement §201.4(b): *The [State] mitigation planning process* ***should*** *include coordination with other State agencies, appropriate Federal agencies, interested groups, and … .*

Element	Location in the Plan (section or annex and page #)	Reviewer's Comments	SCORE N	SCORE S
A. Does the **new or updated** plan describe how Federal and State agencies were involved in the **current** planning process?		***Note: A "Needs Improvement" score on this requirement will not preclude the plan from passing.***		
B. Does the **new or updated** plan describe how interested groups (e.g., businesses, non-profit organizations, and other interested parties) were involved in the **current** planning process?		***Note: A "Needs Improvement" score on this requirement will not preclude the plan from passing.***		
C. Does the updated plan discuss how coordination among Federal and State agencies changed since approval of the previous plan?				
		SUMMARY SCORE		

Program Integration

Requirement §201.4(b): *[The State mitigation planning process* ***should****] be integrated to the extent possible with other ongoing State planning efforts as well as other FEMA mitigation programs and initiatives.*

Element	Location in the Plan (section or annex and page #)	Reviewer's Comments	SCORE N	SCORE S
A. Does the **new or updated** plan describe how the State mitigation planning process is integrated with other ongoing State planning efforts?		***Note: A "Needs Improvement" score on this requirement will not preclude the plan from passing.***		
B. Does the **new or updated** plan describe how the State mitigation planning process is integrated with FEMA mitigation programs and initiatives?		***Note: A "Needs Improvement" score on this requirement will not preclude the plan from passing.***		
		SUMMARY SCORE		

RISK ASSESSMENT: *§201.4(c)(2): [The State plan must include a risk assessment] that provides the factual basis for activities proposed in the strategy portion of the mitigation plan. Statewide risk assessments must characterize and analyze natural hazards and risks to provide a statewide overview. This overview will allow the State to compare potential losses throughout the State and to determine their priorities for implementing mitigation measures under the strategy, and to prioritize jurisdictions for receiving technical and financial support in developing more detailed local risk and vulnerability assessments.*

Identifying Hazards

Requirement §201.4(c)(2)(i): *[The State risk assessment **shall** include an] overview of the type … of all natural hazards that can affect the State … .*

Element	Location in the Plan (section or annex and page #)	Reviewer's Comments	SCORE N	SCORE S
A. Does the **new or updated** plan provide a description of the type of **all natural hazards** that can affect the State? If the hazard identification omits (without explanation) any hazards commonly recognized as threats to the State, this part of the plan cannot receive a Satisfactory score.				
		SUMMARY SCORE		

Profiling Hazards

Requirement §201.4(c)(2)(i): *[The State risk assessment **shall** include an overview of the] location of all natural hazards that can affect the State, including information on previous occurrences of hazard events, as well as the probability of future hazard events, using maps where appropriate … .*

Element	Location in the Plan (section or annex and page #)	Reviewer's Comments	SCORE N	SCORE S
A. Does the risk assessment identify the **location** (i.e., geographic area affected) of each natural hazards addressed in the **new or updated** plan?				
B. Does the **new or updated** plan provide information on **previous occurrences** of each hazard addressed in the plan?				
C. Does the **new or updated** plan include the **probability of future events** (i.e., chance of occurrence) for each hazard addressed in the plan?				
		SUMMARY SCORE		

Assessing Vulnerability

Requirement §201.4(c)(2)(ii): *[The State risk assessment **shall** include an] overview and analysis of the State's vulnerability to the hazards described in this paragraph (c)(2), based on estimates provided in local risk assessments as well as the State risk assessment. The State **shall** describe vulnerability in terms of the jurisdictions most threatened by the identified hazards, and most vulnerable to damage and loss associated with hazard events. State owned critical or operated facilities located in the identified hazard areas shall also be addressed . . . .*

Requirement §201.4(d): Plan must be reviewed and revised to reflect changes in development…

Assessing Vulnerability by Jurisdiction

Element	Location in the Plan (section or annex and page #)	Reviewer's Comments	SCORE N	SCORE S
A. Does the **new or updated** plan describe the State's vulnerability based on estimates provided in local risk assessments as well as the State risk assessment?				
B. Does the **new or updated** plan describe the State's vulnerability in terms of the jurisdictions most threatened and most vulnerable to damage and loss associated with hazard event(s)?				
C. Does the updated plan explain the process used to analyze the information from the local risk assessments, as necessary?				
D. Does the updated plan reflect changes in development for jurisdictions in hazard prone areas?				
		SUMMARY SCORE		

Assessing Vulnerability of State Facilities

Element	Location in the Plan (section or annex and page #)	Reviewer's Comments	SCORE N	SCORE S
A. Does the **new or updated** plan describe the types of State owned or operated critical facilities located in the identified hazard areas?				
		SUMMARY SCORE		

Estimating Potential Losses

Requirement §201.4(c)(2)(iii): *[The State risk assessment **shall** include an] overview and analysis of potential losses to the identified vulnerable structures, based on estimates provided in local risk assessments as well as the State risk assessment. The State **shall** estimate the potential dollar losses to State owned or operated buildings, infrastructure, and critical facilities located in the identified hazard areas.*

Requirement §201.4(d): Plan must be reviewed and revised to reflect changes in development…

Estimating Potential Losses by Jurisdiction

Element	Location in the Plan (section or annex and page #)	Reviewer's Comments	SCORE N	SCORE S
A. Does the **new or updated** plan present an overview and analysis of the potential losses to the identified vulnerable structures?				
B. Are the potential losses based on estimates provided in local risk assessments as well as the State risk assessment?				
C. Does the updated plan reflect the effects of changes in development on loss estimates?				
		SUMMARY SCORE		

Estimating Potential Losses of State Facilities

Element	Location in the Plan (section or annex and page #)	Reviewer's Comments	SCORE N	SCORE S
A. Does the **new or updated** plan present an estimate of the potential dollar losses to State owned or operated buildings, infrastructure, and critical facilities in the identified hazard areas?				
		SUMMARY SCORE		

MITIGATION STRATEGY: *§201.4(c)(3) [To be effective the plan must include a] Mitigation Strategy that provides the State's blueprint for reducing the losses identified in the risk assessment.*

Hazard Mitigation Goals

Requirement §201.4(c)(3)(i): *[The State mitigation strategy **shall** include a] description of State goals to guide the selection of activities to mitigate and reduce potential losses.*

Requirement §201.4(d): Plan must be reviewed and revised to reflect changes in development, progress in statewide mitigation efforts, and changes in priorities…

Element	Location in the Plan (section or annex and page #)	Reviewer's Comments	SCORE N	SCORE S
A. Does the **new or updated** plan provide a description of State mitigation **goals** that guide the selection of mitigation activities?				
B. Does the updated plan demonstrate that the goals were assessed and either remain valid or have been revised?				
		SUMMARY SCORE		

State Capability Assessment ***Requirement §201.4(c)(3)(ii):*** *[The State mitigation strategy **shall** include a] discussion of the State's pre-and post-disaster hazard management policies, programs, and capabilities to mitigate the hazards in the area, including: an evaluation of State laws, regulations, policies, and programs related to hazard mitigation as well as to development in hazard-prone areas [and] a discussion of State funding capabilities for hazard mitigation projects … .*

Element	Location in the Plan (section or annex and page #)	Reviewer's Comments	SCORE N	SCORE S
A. Does the **new or updated** plan include an evaluation of the State's **pre-disaster** hazard management policies, programs, and capabilities?				
B. Does the **new or updated** plan include an evaluation of the State's **post-disaster** hazard management policies, programs, and capabilities?				
C. Does the **new or updated** plan include an evaluation of the State's policies related to **development in hazard prone areas**?				
D. Does the **new or updated** plan include a discussion of State				

funding capabilities for hazard mitigation projects?				
E. Does the updated plan address any hazard management capabilities of the State that have changed since approval of the previous plan?				
		SUMMARY SCORE		

Local Capability Assessment

Requirement §201.4(c)(3)(ii): *[The State mitigation strategy **shall** include] a general description and analysis of the effectiveness of local mitigation policies, programs, and capabilities.*

Element	**Location in the Plan** (section or annex and page #)	Reviewer's Comments	SCORE N	SCORE S
A. Does the **new or updated** plan present a general description of the local mitigation policies, programs, and capabilities?				
B. Does the **new or updated** plan provide a general analysis of the effectiveness of local mitigation policies, programs, and capabilities?				
		SUMMARY SCORE		

Mitigation Actions

Requirement §201.4(c)(3)(iii): *[State plans **shall** include an] identification, evaluation, and prioritization of cost-effective, environmentally sound, and technically feasible mitigation actions and activities the State is considering and an explanation of how each activity contributes to the overall mitigation strategy. This section **should** be linked to local plans, where specific local actions and projects are identified.*

Requirement §201.4(d): Plan must be reviewed and revised to reflect changes in development, progress in statewide mitigation efforts, and changes in priorities…

Element	**Location in the Plan** (section or annex and page #)	Reviewer's Comments	SCORE N	SCORE S
A. Does the **new or updated** plan identify cost-effective, environmentally sound, and technically feasible mitigation actions and activities the State is considering?				
B. Does the **new or updated** plan evaluate these actions and activities?				
C. Does the **new or updated** plan prioritize these actions and activities?				
D. Does the **new or updated** plan explain how each activity contributes to the overall State mitigation strategy?				

E. Does the mitigation strategy **in the new or updated** section reflect actions and projects identified in local plans?		***Note: A "Needs Improvement" score on this requirement will not preclude the plan from passing.***		
		SUMMARY SCORE		

Funding Sources

Requirement §201.4(c)(3)(iv): *[The State mitigation strategy **shall** include an] identification of current and potential sources of Federal, State, local, or private funding to implement mitigation activities.*

Element	Location in the Plan (section or annex and page #)	Reviewer's Comments	SCORE N	SCORE S
A. Does the **new or updated** plan identify **current** sources of Federal, State, local, or private funding to implement mitigation activities?				
B. Does the **new or updated** plan identify **potential** sources of Federal, State, local, or private funding to implement mitigation activities?				
C. Does the updated plan identify the sources of mitigation funding used to implement activities in the mitigation strategy since approval of the previous plan?				
		SUMMARY SCORE		

COORDINATION OF LOCAL MITIGATION PLANNING

Local Funding and Technical Assistance

Requirement §201.4(c)(4)(i): *[The section on the Coordination of Local Mitigation Planning **must** include a] description of the State process to support, through funding and technical assistance, the development of local mitigation plans.*

Element	Location in the Plan (section or annex and page #)	Reviewer's Comments	SCORE N	SCORE S
A. Does the **new or updated** plan provide a description of the State process to support, through funding and technical assistance, the development of local mitigation plans?				
B. Does the updated plan describe the funding and technical assistance the State has provided in the past three years to assist local jurisdictions in completing approvable mitigation plans?				
		SUMMARY SCORE		

Local Plan Integration

Requirement §201.4(c)(4)(ii): *[The section on the Coordination of Local Mitigation Planning* ***must*** *include a] description of the State process and timeframe by which the local plans will be reviewed, coordinated, and linked to the State Mitigation Plan.*

Requirement §201.4(d): Plan must be reviewed and revised to reflect changes in development, progress in statewide mitigation efforts, and changes in priorities…

Element	Location in the Plan (section or annex and page #)	Reviewer's Comments	SCORE N	SCORE S
A. Does the **new or updated** plan provide a description of the **process and timeframe** the State established to **review** local plans?				
B. Does the **new or updated** plan provide a description of the **process and timeframe** the State established to **coordinate and link** local plans to the State Mitigation Plan?				
		SUMMARY SCORE		

Prioritizing Local Assistance

Requirement §201.4(c)(4)(iii): *[The section on the Coordination of Local Mitigation Planning **must** include] criteria for prioritizing communities and local jurisdictions that would receive planning and project grants under available funding programs, which **should** include consideration for communities with the highest risks, repetitive loss properties, and most intense development pressures.*

*Further, that for non-planning grants, a principal criterion for prioritizing grants **shall** be the extent to which benefits are maximized according to a cost benefit review of proposed projects and their associated costs.*

Requirement §201.4(d): Plan must be reviewed and revised to reflect changes in development, progress in statewide mitigation efforts, and changes in priorities…

Element	Location in the Plan (section or annex and page #)	Reviewer's Comments	SCORE N	SCORE S
A. Does the **new or updated** plan provide a description of the criteria for prioritizing those communities and local jurisdictions that would receive planning and project grants under available mitigation funding programs?				
B. **For the new or updated plan, do** the prioritization criteria include, for non-planning grants, the consideration of the extent to which benefits are maximized according to a cost benefit review of proposed projects and their associated cost?				
C. **For the new or updated plan, do** the criteria include considerations for communities with the highest risk?		***Note: A "Needs Improvement" score on this requirement will not preclude the plan from passing.***		
D. **For the new or updated plan, do** the criteria include considerations for repetitive loss properties?		***Note: A "Needs Improvement" score on this requirement will not preclude the plan from passing.***		
E. **For the new or updated plan, do** the criteria include considerations for communities with the most intense development pressures?		***Note: A "Needs Improvement" score on this requirement will not preclude the plan from passing.***		
		SUMMARY SCORE		

PLAN MAINTENANCE PROCESS

Monitoring, Evaluating, and Updating the Plan ***Requirement §201.4(c)(5)(i):*** *[The Standard State Plan Maintenance Process **must** include an] established method and schedule for monitoring, evaluating, and updating the plan.*

Element	Location in the Plan (section or annex and page #)	Reviewer's Comments	SCORE N	SCORE S
A. Does the **new or updated** plan describe the method and schedule for monitoring the plan? (e.g., identifies the party responsible for **monitoring**, includes schedule for reports, site visits, phone calls, and/or meetings)				
B. Does the **new or updated** plan describe the method and schedule for **evaluating** the plan? (e.g., identifies the party responsible for evaluating the plan, includes the criteria used to evaluate the plan)				
C. Does the **new or updated** plan describe the method and schedule for **updating** the plan?				
D. Does the updated plan include an analysis of whether the previously approved plan's method and schedule worked, and what elements or processes, if any, were changed?				
		SUMMARY SCORE		

Monitoring Progress of Mitigation Activities ***Requirement §201.4(c)(5)(ii):*** *[The Standard State Plan Maintenance Process **must** include a] system for monitoring implementation of mitigation measures and project closeouts. Requirement **§201.4(c)(5)(iii):*** *[The Standard State Plan Maintenance Process **must** include a] system for reviewing progress on achieving goals as well as activities and projects in the Mitigation Strategy.*

Element	Location in the Plan (section or annex and page #)	Reviewer's Comments	SCORE N	SCORE S
A. Does the **new or updated** plan describe how mitigation measures and project closeouts will be monitored?				
B. Does the **new or updated** plan identify a system for reviewing progress on achieving goals in the Mitigation Strategy?				
C. Does the updated plan describe any modifications, if any, to the system identified in the previously approved plan to track the initiation, status, and completion of mitigation activities?				
D. Does the **new or updated** plan identify a system for reviewing progress on implementing activities and projects of the Mitigation Strategy?				
E. Does the updated plan discuss if mitigation actions were implemented as planned?		***Note: Related to §201.4 (c)(3)(iii)***		
		SUMMARY SCORE		

SEVERE REPETITIVE LOSS STRATEGY *(only required for 90/10 under FMA & SRL)*

Repetitive Loss Mitigation Strategy

Requirement §201.4(c)(3)(v): *A State may request the reduced cost share authorized under §79.4(c)(2) of this chapter for the FMA and SRL programs, if it has an approved State Mitigation Plan … that also identifies specific actions the State has taken to reduce the number of repetitive loss properties (which* ***must*** *include severe repetitive loss properties), and specifies how the State intends to reduce the number of such repetitive loss properties.*

Element	Location in the Plan (section or annex and page #)	Reviewer's Comments	SCORE NOT MET	SCORE MET
A. Does the new or updated plan describe State mitigation goals that support the selection of mitigation activities for repetitive loss properties (see also Part 201.4(c)(3)(i))?		***[Note: Only required for SRL 90/10 under FMA & SRL]***		
B. Does the new or updated plan consider repetitive loss properties in its evaluation of the State's hazard management policies, programs, and capabilities and its general description of the local mitigation capabilities (see also Part 201.4(c)(3)(ii))?		***[Note: Only required for SRL 90/10 under FMA & SRL]***		
C. Does the new or updated plan address repetitive loss properties in its risk assessment (see also Part 201.4(c)(2))?		***[Note: Only required for SRL 90/10 under FMA & SRL]***		
D. Does the new or updated plan identify, evaluate and prioritize cost-effective, environmentally sound, and technically feasible mitigation actions for repetitive loss properties (see also Part 201.4(c)(3)(iii))?		***[Note: Only required for SRL 90/10 under FMA & SRL]***		
E. Does the new or updated plan describe specific actions that have been implemented to mitigate repetitive loss properties, including actions taken to reduce the number of severe repetitive loss properties?		***[Note: Only required for SRL 90/10 under FMA & SRL]***		
F. Does the new or updated plan identify current and potential sources of Federal, State, local, or private funding to implement mitigation activities for repetitive loss properties (see also Part 201.4(c)(3)(iv))?		***[Note: Only required for SRL 90/10 under FMA & SRL]***		
		SUMMARY SCORE		

Coordination with Repetitive Loss Jurisdictions

Requirement §201.4(c)(3(v): *In addition, the plan* ***must*** *describe the strategy the State has to ensure that local jurisdictions with severe repetitive loss properties take actions to reduce the number of these properties, including the development of local mitigation plans.*

Element	Location in the Plan (section or annex and page #)	Reviewer's Comments	SCORE N	SCORE S
A. Does the new or updated plan provide a description of the State process to support, through funding and technical assistance, the development of local mitigation plans in communities with severe repetitive loss properties (see also Part 201.4(c)(4)(i))?		***[Note: Only required for SRL 90/10 under FMA & SRL]***		
B. Does the new or updated plan include considerations for repetitive loss properties in its criteria for prioritizing communities and local jurisdictions that would receive planning and project grants under available mitigation funding programs (see also Part 201.4(c)(3)(iii))?		***[Note: Only required for SRL 90/10 under FMA & SRL]***		
		SUMMARY SCORE		

Matrix A: Profiling Hazards

This matrix can assist FEMA in scoring each hazard. States may find the matrix useful to ensure that their plan addresses each natural hazard that can affect the State. **Completing the matrix is not required.**

Note: First, check which hazards are identified in requirement §201.4(c)(2)(i). Then, place a checkmark in either the N or S box for each ***applicable*** *hazard. An "N" for any element of any identified hazard will result in a "Needs Improvement" score for this requirement. List the hazard and its related shortcoming in the comments section of the Plan Review Crosswalk.*

Hazard Type	Hazards Identified Per Requirement §201.4(c)(2)(i)	A. Location		B. Previous Occurrences		C. Probability of Future Events	
	Yes	N	S	N	S	N	S
Avalanche	☐	☐	☐	☐	☐	☐	☐
Coastal Erosion	☐	☐	☐	☐	☐	☐	☐
Coastal Storm	☐	☐	☐	☐	☐	☐	☐
Dam Failure	☐	☐	☐	☐	☐	☐	☐
Drought	☐	☐	☐	☐	☐	☐	☐
Earthquake	☐	☐	☐	☐	☐	☐	☐
Expansive Soils	☐	☐	☐	☐	☐	☐	☐
Extreme Heat	☐	☐	☐	☐	☐	☐	☐
Flood	☐	☐	☐	☐	☐	☐	☐
Hailstorm	☐	☐	☐	☐	☐	☐	☐
Hurricane	☐	☐	☐	☐	☐	☐	☐
Land Subsidence	☐	☐	☐	☐	☐	☐	☐
Landslide	☐	☐	☐	☐	☐	☐	☐
Levee Failure	☐	☐	☐	☐	☐	☐	☐
Severe Winter Storm	☐	☐	☐	☐	☐	☐	☐
Tornado	☐	☐	☐	☐	☐	☐	☐
Tsunami	☐	☐	☐	☐	☐	☐	☐
Volcano	☐	☐	☐	☐	☐	☐	☐
Wildfire	☐	☐	☐	☐	☐	☐	☐
Windstorm	☐	☐	☐	☐	☐	☐	☐
Other _____	☐	☐	☐	☐	☐	☐	☐
Other _____	☐	☐	☐	☐	☐	☐	☐
Other _____	☐	☐	☐	☐	☐	☐	☐

To check boxes, double click on the box and change the default value to "checked."

Legend:
§201.4(c)(2)(i) Profiling Hazards
A. Does the risk assessment identify the location (i.e., geographic area affected) of each natural hazard addressed in the **new or updated** plan?
B. Does the plan provide information on previous occurrences of each hazard addressed in the **new or updated** plan?
C. Does the plan include the probability of future events (i.e., chance of occurrence) for each hazard addressed in the **new or updated** plan?

Matrix B: Assessing Vulnerability

This matrix can assist FEMA in scoring each hazard. States may find the matrix useful to ensure that their plan addresses each requirement. Note that this matrix only includes items for Requirements §201.4(c)(2)(ii) and §201.4(c)(2)(iii) that are related to specific natural hazards that can affect the State. **Completing the matrix is not required**.

Note: First, check which hazards are identified in requirement §201.4(c)(2)(i). Then, place a checkmark in either the N or S box for each ***applicable*** *hazard. An "N" for any element of any identified hazard will result in a "Needs Improvement" score for this requirement. List the hazard and its related shortcoming in the comments section of the Plan Review Crosswalk.*

Hazard Type	Hazards Identified Per Requirement §201.4(c)(2)(i)	§201.4(c)(2)(ii) Assessing Vulnerability					§201.4(c)(2)(iii) Estimating Potential Losses			
		1. Vulnerability by Jurisdiction		2. Vulnerability to State Facilities			3. Loss Estimate by Jurisdiction		4. Loss Estimate of State Facilities	
	Yes	N	S	N	S		N	S	N	S
Avalanche	☐	☐	☐	☐	☐		☐	☐	☐	☐
Coastal Erosion	☐	☐	☐	☐	☐		☐	☐	☐	☐
Coastal Storm	☐	☐	☐	☐	☐		☐	☐	☐	☐
Dam Failure	☐	☐	☐	☐	☐		☐	☐	☐	☐
Drought	☐	☐	☐	☐	☐		☐	☐	☐	☐
Earthquake	☐	☐	☐	☐	☐		☐	☐	☐	☐
Expansive Soils	☐	☐	☐	☐	☐		☐	☐	☐	☐
Extreme Heat	☐	☐	☐	☐	☐		☐	☐	☐	☐
Flood	☐	☐	☐	☐	☐		☐	☐	☐	☐
Hailstorm	☐	☐	☐	☐	☐		☐	☐	☐	☐
Hurricane	☐	☐	☐	☐	☐		☐	☐	☐	☐
Land Subsidence	☐	☐	☐	☐	☐		☐	☐	☐	☐
Landslide	☐	☐	☐	☐	☐		☐	☐	☐	☐
Levee Failure	☐	☐	☐	☐	☐		☐	☐	☐	☐
Severe Winter Storm	☐	☐	☐	☐	☐		☐	☐	☐	☐
Tornado	☐	☐	☐	☐	☐		☐	☐	☐	☐
Tsunami	☐	☐	☐	☐	☐		☐	☐	☐	☐
Volcano	☐	☐	☐	☐	☐		☐	☐	☐	☐
Wildfire	☐	☐	☐	☐	☐		☐	☐	☐	☐
Windstorm	☐	☐	☐	☐	☐		☐	☐	☐	☐
Other _____	☐	☐	☐	☐	☐		☐	☐	☐	☐
Other _____	☐	☐	☐	☐	☐		☐	☐	☐	☐
Other _____	☐	☐	☐	☐	☐		☐	☐	☐	☐

To check boxes, double click on the box and change the default value to "checked."

Legend

§201.4(c)(2)(ii) Assessing Vulnerability by Jurisdiction (see element B)

1. Does the **new or updated** plan describe the State's vulnerability in terms of the jurisdictions most threatened and most vulnerable to damage and loss associated with hazard event(s)?

§201.4(c)(2)(ii) Assessing Vulnerability to State Facilities (see element A)

2. Does the **new or updated** plan describe the types of State owned or operated critical facilities located in the identified hazard areas?

§201.4(c)(2)(iii) Estimating Potential Losses by Jurisdiction (see element A)

3. Does the **new or updated** plan present an overview and analysis of the potential losses to the identified vulnerable structures?

§201.4(c)(2)(iii) Estimating Potential Losses of State Facilities (see element A)

4. Does the **new or updated** plan present an estimate of the potential dollar losses to State owned or operated buildings, infrastructure, and critical facilities in the identified hazard areas?

Name and date/edition of plan_____ reviewed by _____ on _____
Type of plan: ___ SINGLE JURISDICTION PLAN; ___ MULTI-JURISDICTIONAL PLAN; Update of previously approved plan? _____
(% estimates given below for required items: first % for a single jurisdiction's DMA plan; second % for multijurisdictional plan) *FEMA crosswalk item # follows*

Section One – Planning Preliminaries (Preparation, Participation, Process), Items 1-11 = 30% possible. Review total = _____%

_____ 1. Has the local governing body adopted the new or updated plan? **(0, 0)** *1A* Pages _____

_____ 2. Is supporting documentation, such as a resolution, included? **(0, 0)** *1B* Pages _____

_____ 3. **MULTIJURISDICTIONAL PLANS ONLY:** Does the new or updated plan indicate the specific jurisdictions represented in (i.e. participating and requesting grant eligibility from) the multi-jurisdictional plan? **(0, 3%)** *2A*
Pages _____

3a. **Updated plans only:** Does the updated plan specify each jurisdiction's status as either a new participant, a continuing participant, or a non-participant in the updated plan? *3B* Pages_____

_____ 4. **MULTIJURISDICTIONAL PLANS ONLY:** For each jurisdiction, has the local governing body adopted the new or updated plan? **(0, 0)** *2B* Pages_____

_____ 5. **MULTIJURISDICTIONAL PLANS ONLY:** Is supporting documentation, such as a resolution, included for each participating jurisdiction? **(0, 0)** *2C* Pages _____

_____ 6. **MULTIJURISDICTIONAL PLANS ONLY:** Does the new or updated plan describe how each jurisdiction participated in the plan's development? **(0, 4%)** *3A* Pages _____

_____ 7. Does the new or updated plan provide a narrative description of the process followed to prepare the plan? **(7%, 5%)** *4A*
Pages _____

7a. **Updated plans only:** Does the updated plan document how the planning team reviewed and analyzed each section of the plan and whether each section was revised as part of the update process? *4F*
Pages _____

_____ 8. Does the new or updated plan indicate who was involved in the planning process? (For example, who led the development at the staff level and who were any external contributors such as contractors? Who participated on the plan committee, provided information, reviewed drafts, etc.?) **(4%, 3%)** *4B* Pages _____

_____ 9. Does the new or updated plan indicate how the public was involved? (Was the public provided an opportunity to comment on the plan during the drafting stage and prior to plan approval?) **(6%, 5%)** *4C*
Pages _____

_____ 10. Does the new or updated plan discuss the opportunity for neighboring communities, agencies, businesses, academia, nonprofits, and other interested parties to be involved in the planning process? **(7%, 5%)** *4D*
Pages _____

_____ 11. Does the planning process describe the review and incorporation, if appropriate, of existing plans, studies, reports, and technical information? **(6%, 5%)** *4E* Pages _____

Section Two – Hazard Analysis Section, Items 12-23 = 30% possible. Review total = %

_____ 12. Does the new or updated plan include a description of the types of all natural hazards that affect the jurisdiction? **(3%, 3%)** *5A* Pages _____

_____ 13. Does the risk assessment identify the location (i.e., geographic area affected) of each natural hazard addressed in the new or updated plan? **(6%, 5%)** *6A* Pages _____

_____ 14. Does the risk assessment identify the extent (i.e., magnitude or severity) of each hazard addressed in the new or updated plan? **(3%, 2%)** *6B* Pages _____

_____ 15. Does the plan provide information on previous occurrences of each hazard addressed in the new or updated plan? **(6%, 5%)** *6C* Pages _____

_____ 16. Does the plan include the probability of future events (i.e., chance of occurrence) for each hazard addressed in the new or updated plan? **(4%, 3%)** *6D* Pages _____

_____ 17. Does the new or updated plan include an overall summary description of the jurisdiction's vulnerability to each hazard? **(3%, 2%)** *7A* Pages _____

_____ 18. Does the new or updated plan address the impact of each hazard on the jurisdiction? **(2%, 2%)** *7B*
Pages _____

_____ 19. Does the new or updated plan describe vulnerability in terms of the types and numbers of repetitive loss properties located in the identified hazard areas? **(3%, 3%)** *8A* Pages _____

19a. **NOT REQUIRED:** Does the new or updated plan describe vulnerability in terms of the types and numbers of existing buildings, infrastructure, and critical facilities located in the identified hazard areas? **(0, 0)** *9A*
Pages _____

19b. **NOT REQUIRED:** Does the new or updated plan describe vulnerability in terms of the types and numbers of future buildings, infrastructure, and critical facilities located in the identified hazard areas? **(0, 0)** *9B*
Pages _____

20. **NOT REQUIRED:** Does the new or updated plan estimate potential dollar losses to vulnerable structures? **(0, 0)** *10A*
Pages _____

21. **NOT REQUIRED:** Does the new or updated plan describe the methodology used to prepare the estimate (for item 20)? **(0, 0)** *10B* Pages _____

22. **NOT REQUIRED:** Does the new or updated plan describe land uses and development trends? **(0, 0)** *11A*
Pages _____

_____ 23. **MULTIJURISDICTIONAL PLANS ONLY:** Does the new or updated plan include a risk assessment for each participating jurisdiction as needed to reflect unique or varied risks? **(0, 5%)** *12A*
Pages _____

Section Three – Action Plan Section, Items 24-30 = 30% possible; review total = _____%

_____ 24. Does the new or updated plan include a description of mitigation goals to reduce or avoid long-term vulnerabilities from the identified hazards? (GOALS are long-term, represent what the community wants to achieve, such as "eliminate flood damage," and are based on the risk assessment findings.) **(3%, 3%)** *13A* Pages _____

_____ 25. Does the new or updated plan identify and analyze a comprehensive range of specific mitigation actions and projects for each hazard? **(6%, 6%)** *14A* Pages _____

_____ 26. Do the identified actions and projects address reducing the effects of hazards on new buildings and infrastructure? **(4%, 3%)** *14B* Pages _____

26a. Does the plan identify other local planning mechanisms (including land use development plans) available for incorporating issues and actions from the mitigation plan? *19A* Pages _____

26b. Does the new or updated plan include a process by which the local government will incorporate the mitigation strategy and other information (e.g. risk assessment) into other planning mechanisms (especially community master plans), when appropriate? *19B* Pages _____

26c. **Updated plans only:** Does the updated plan explain how the local government(s) incorporated the mitigation strategy and other information (e.g. risk assessment) into other planning mechanisms (especially community master plans), when appropriate? *19C* Pages _____

_____ 27. Do the identified actions and projects address reducing the effects of hazards on existing buildings and infrastructure (including elements appropriate for FEMA hazard mitigation grant funding)? **(4%, 3%)** *14C*
Pages _____

27a. Does the new or updated plan list the NFIP participation status of the jurisdiction(s) represented (plus the availability and use of a digital Flood Insurance Rate Map)? *15A* Pages _____

27b. Does the new or updated mitigation strategy identify, analyze, and prioritize actions related to NFIP compliance? *15B*
Pages _____

_____ 28. Does the new or updated mitigation strategy include how the actions are prioritized? (For example, is there a discussion of the process and criteria used?) **(5%, 4%)** *16A* Pages _____

28a. Does the new or updated prioritization process include an emphasis on the use of a cost-benefit review to maximize benefits (see page 63 of FEMA's July 1, 2008 Multi-Hazard Mitigation Planning Guidance)? *16C*
Pages _____

_____ 29. Does the new or updated mitigation strategy address how the actions will be implemented and administered? (For example, the responsible department, existing and potential resources, and timeframe?) **(8%, 6%)** *16B*
Pages _____

29a. **Updated plans only:** Does the updated plan identify the completed, deleted, or deferred mitigation actions as a benchmark for progress, and describe why any unchanged activities have not been changed? *16D*
Pages _____

_____ 30. **MULTIJURISDICTIONAL PLANS ONLY:** Does the new or updated plan include identifiable action items for each jurisdiction requesting FEMA approval of the plan? **(0, 5%)** *17A* Pages _____

30a. **Updated plans only:** Does the updated plan identify the completed, deleted, or deferred mitigation actions as a benchmark for progress, and describe why any unchanged activities have not been changed? *17B* Pages _____

Section Four – Maintenance/Implementation Section & State Requirements, Items 31-37 = 10% possible. Review total = ____ %

_____ 31. Does the new or updated plan describe the method and schedule for monitoring the plan, including the responsible department? **(1%, 1%)** *18A* Pages _____

_____ 32. Does the new or updated plan describe the method and schedule for evaluating the plan, including how (e.g. criteria used), when, and by whom (i.e. the responsible department)? **(2%, 2%)** *18B* Pages _____

_____ 33. Does the new or updated plan describe the method and schedule for updating the plan within the five-year cycle? **(1%, 1%)** *18C* Pages _____

_____ 34. Does the new or updated plan explain how continued public participation will be obtained? (For example, will there be public notices, an on-going mitigation plan committee, or annual review meetings with stakeholders?) **(1%, 1%)** *20A* Pages _____

_____ 35. **STATE REQUIREMENT:** Does the plan describe or map current warning system coverage (especially outdoor sirens) within the planning area? **(3%, 3%)** Pages _____

_____ 36. **STATE REQUIREMENT:** Does the plan describe whether the planning area has been zoned (or uses other mechanisms for regulating development) and what level of government (i.e. village, township, city, county, or region) currently has authority over those zoning or other development regulations in the planning area? (Is this information provided for each jurisdiction, in multi-jurisdictional plans?) **(2%, 2%)**
Pages _____

37. **NOT REQUIRED**: Does the plan describe how consideration was given, during the plan development or update process, to those hazard mitigation goals, priorities, and information contained in the most current edition of the Michigan Hazard Mitigation Plan? **(0,0)** Pages _____

TOTAL OF ESTIMATED PERCENT VALUES (APPROXIMATE AMOUNT OF PLAN COMPLETED):_____%

Is EMHSD willing to recommend plan approval to FEMA? ___ Yes; ___ Yes – but revisions are recommended before submission; ___ Not yet – revisions are required before approval can be recommended; ___ No – this was a preliminary review of draft materials

PLAN REVIEW COMMENTS, OR PLACES WHERE SPECIFIC CORRECTIONS ARE RECOMMENDED:

_____

_____

_____

_____

_____

_____

_____

_____

_____

ARE MORE REVIEWER NOTES ADDED ON ADDITIONAL PAGES? No: ____, Yes:_____

(This page reserved for future use.)