SUSTAINING
MICHIGAN'S WATER HERITAGE

A Strategy for the Next Generation

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Governor's Foreword

Michigan has an unparalleled system of thousands of lakes, streams, wetlands, beaches and groundwater resources. This vast water network – combined with our unique position within the Great Lakes, the world's largest freshwater system – provides us exceptional opportunities. But, it also means we have a great responsibility to ensure the healthiest water system in the world.

Michigan's water system provides drinking water to millions of people, creates unique and pristine habitats and provides for world-class recreation opportunities found nowhere else on Earth. We rely on this system for public health, environmental, recreational and economic benefits. To sustain Michigan's future, we must manage Michigan's water resources wisely in ways that protect and enhance their value.

Michigan's Water Strategy will, for the first time in our state's history, outline a vision for the future for managing, protecting and enhancing one of our greatest natural assets: abundant freshwater resources.

This Water Strategy will guide the decision makers of our state on sound water policy and it will help align the actions of the various stakeholders involved in water resource planning with a focus on water stewardship. However, there are a few critical areas the state needs to focus on immediately. With the release of this Water Strategy, I am directing my administration to focus the state's actions on five key priorities. These priorities, under the leadership of their designated departments, will be developed in more extensive detail over the coming months. These priorities will emphasize and align the protection of public health and the sustainable use of our natural resources to enrich the quality of life and economic vitality in Michigan's local communities.

1. Ensure safe drinking water

We need to ensure Michigan has reliable water infrastructure systems in place to safeguard the public health of all residents. Sound infrastructure systems are critical to providing high-quality drinking water and optimal treatment of our sewer and storm water.

2. Achieve a 40% phosphorus reduction in the western Lake Erie basin

Reducing the amount of phosphorus in the Lake Erie Basin will help reduce harmful algal blooms and improve water quality for both drinking water and ecosystem health.

3. Prevent the introduction of new aquatic invasive species and control established populations

Invasive species are one of the most significant threats to our nation's lands and waters. The native ecosystems of the Great Lakes and Michigan's inland waters are at risk of being forever changed. Our local natural resource-based economies that depend on tourism for their livelihood are at risk of collapse if invasive species enter the Great Lakes.

4. Support investments in commercial and recreational harbors

Our harbors serve as both a recreational and economic asset for local communities, helping to create vibrant waterfronts for boaters, anglers, residents and businesses. Michigan's 80 recreational harbors also help to support the state's $4 billion boating industry. Integrating harbors into community and economic development planning can help to prioritize and leverage capital investments necessary to improve and maintain harbor infrastructure and dredging needs.

Our commercial ports also serve a vital role in the economic vitality of our local communities and the Great Lakes Basin. Strategic investments in our ports and port infrastructure will help to enhance existing markets and create new markets to improve Michigan's position in Great Lakes maritime commerce.

5. Develop and implement a water trails system

Water trails are integral to a comprehensive statewide trail strategy. They help spur economic development along Michigan's waterways, increase access to natural resources and benefit local communities.

The details of how we will work on these five priorities will be outlined in specific implementation plans crafted by each lead state agency over the next few months. Through our combined efforts, we can provide an unparalleled quality of life for all people in Michigan. We owe this to all Michiganders now and well into the future.

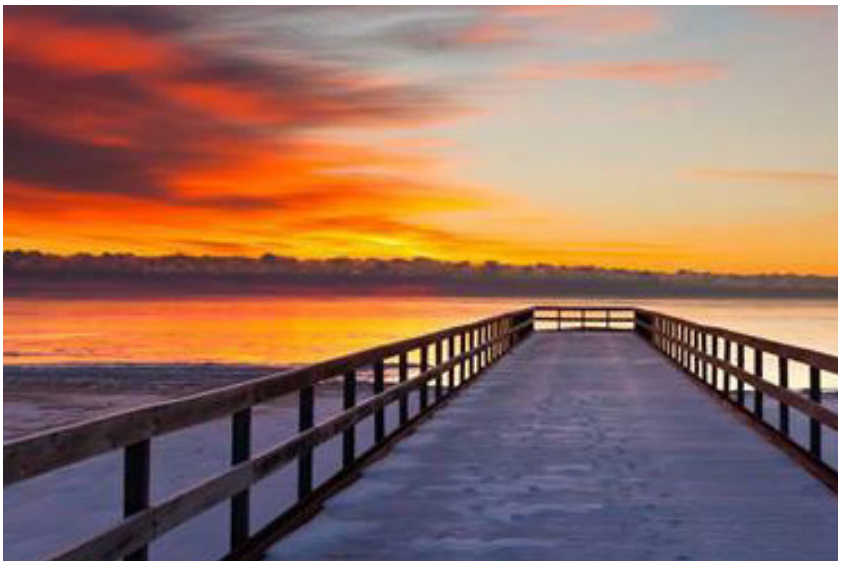
Rick Snyder,

Governor

VISION

As the Great Lakes State, Michigan will protect and promote wise use of its globally unique water resources to ensure healthy citizens, vibrant communities, sustainable economies and the stewardship of Michigan's water heritage.

Executive Summary



Water defines Michigan. It is deeply rooted in the state's culture, heritage and economy. With 20 percent of the world's available freshwater, four of the Great Lakes, more than 11,000 inland lakes, 76,000 miles of rivers, 6.5 million acres of wetlands and more than 3,200 miles of freshwater coastline - the longest in the world - ensuring the long-term sustainability of this treasured globally significant natural resource is critical to the integrity of the ecosystem, the well-being of nearly 10 million residents and our ability to advance Michigan's prosperity.

A deep connection to water - from the smallest trickling stream to the mighty Great Lakes - shapes the Michigan way of life. Water is a primary character in our stories from the earliest tribal histories through industrial growth to today's vacation destinations. One in five Michigan jobs are tied to our water resources;[1] they are the lifeblood supporting our health, families, values and economic opportunity. The beauty of our lakes and rivers inspires us to be better stewards of our resources and maintain them for today's communities and tomorrow's future.

Michigan's clean, plentiful freshwater is a unique and valuable resource that is growing in importance. The world population is expected to grow from 7 billion to over 9 billion people by 2050,[2] further increasing the growing demand for global freshwater resources. In 2015, a global risk report from the World Economic Forum identified water crises as the number one risk influencing the global economy.[3]

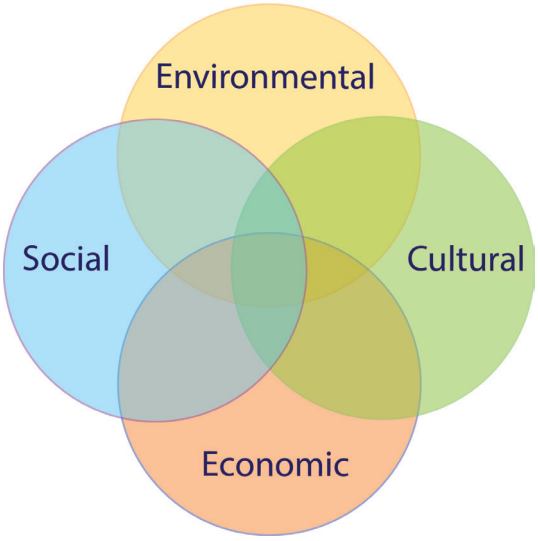
Abundant freshwater resources are at the root of why many Michiganders choose to live, work and play in the peninsula state. Michigan's surface and groundwater resources are vitally important for agricultural production, irrigation, drinking water, electric utilities, mining, manufacturing and water supply to lakes and streams that support valuable fish, waterfowl and wildlife populations. Michigan's abundant water assets and research capabilities, in addition to its highly-skilled talent, economic development expertise, innovation and invention, and powerful tourism and business marketing brand are pivotal drivers for attracting business creation and investment.

With this abundance comes a deep sense of responsibility and stewardship - but Michigan has not always treated its water with a sense of care. Today, the state is slowly returning to a level of aquatic health in many waterways and lakes necessary to fully support diverse fish and wildlife and meaningful recreation in many communities. Through longstanding public and private partnerships and tremendous investment of time and resources, communities are making progress in cleaning up legacy contamination.

But that is just the beginning. The ability to achieve Michigan's vision for its water resources depends on a strategic, collaborative ecosystem-based plan that monitors the health and condition of our water resources, invests in water-related infrastructure, uses water more thoughtfully and efficiently to grow sustainable economies, reconnects communities to water and fosters a water ethic and culture of stewardship.

Michigan's Water Strategy - An Ecosystems Approach

The forthcoming Water Strategy takes an ecosystem approach, focused on the fact that Michiganders are a part of the ecosystem in which we live and therefore have an effect on the health of our water resources. The Strategy recognizes that the core values identified with water are four fold: environmental, economic, social and cultural. All are equally important. Communities across Michigan recognize the value of water quality improvement activities supported through state and federal investments. Studies by the Brookings Institution and Grand Valley State University show that restoring water quality and shorelines respectively, result in a 3-to-1 and 6.6-to-1 return on investment in the form of increased property values, local economic development, improved ecosystem health and quality of life.



Water has immense economic and social value when paired with a healthy environment. Water use by humans is tied to the health of ecosystems and the various fish and wildlife species that occupy them. Social value is represented as how water forms a basis for activity and time with friends and family and how these uses create joy and memories. Cultural value is about identity and affinity to place: where we choose to live and why; who and what we identify with; and where our stories, myths and beliefs come from. For Michiganders, water – and especially the Great Lakes – forms a core part of identity and culture.

The approach recognizes that each of these four values needs to be addressed in balance with the others. They exist together, influence each other and may require compromise, accommodation and limits. This approach is reflected in the Strategy through its goals, outcomes and recommendations.

A Roadmap to Achieve the Vision

The Water Strategy outlines a 30-year vision shaped by a desire for high-quality, accessible water resources that are protected by and for present and future generations based on the question asked in multiple forums around the state: "What do you want Michigan and Michigan's water resources to look like and do over the next generation?" Throughout the development of the Strategy, Michiganders said they care deeply about the Great Lakes, rivers and inland lakes, groundwater and water in general. It is this caring that ultimately drives the ability to support, choose, manage and fund the requirements of healthy water. To that end, the Strategy recognizes that decisions made now regarding infrastructure, innovation and technology, monitoring and water literacy will set the course for decades.

Great Lakes, Water and Governance

The Great Lakes and Michigan's water have long been recognized as valuable resources fundamental to our way of life by federal and provincial governments, tribal nations and the seven other states within the basin. The Great Lakes are a global treasure and thus, protection and restoration must be considered in the context of all who share the resource. While the Strategy is Michigan-specific, coordination with the other Great Lakes states, Canadian provinces, and both the federally-recognized Indian Tribes and First Nations in the Great Lakes area is necessary to fully sustain our water heritage.

The Great Lakes region has long-standing governance and institutional structures, organizations and other formal and informal mechanisms focused on protecting, restoring and maintaining the integrity of this vast water resource. These include the International Joint Commission, Great Lakes Water Quality Agreement, Great Lakes–St. Lawrence River Water Resource Compact Agreement, Conference of Great Lakes - St. Lawrence Governors and Premiers, Great Lakes Commission, Great Lakes Fishery Commission and many others. Federal, state, and tribal laws and regulations also apply to specific water issues. The many layers of this institutional and legal framework create an ongoing need for consultation and collaboration among all of the governments and actors that seek to protect water resources.

For generations, the Indian Tribes have resided in the Great Lakes region and depended on the Great Lakes and Michigan's inland lakes, rivers, streams and groundwater for their way of life. These water resources provide food, transportation and drinking water, in addition to fulfilling many cultural purposes. The State's relationships with the federally-recognized tribes in Michigan are an important part of the governance landscape for water in the Great Lakes region. The State is a party to federal consent decrees with five tribes that govern, among other things, both inland and Great Lakes fishing to manage the fisheries and give effect to those tribes' reserved rights under treaties with the United States. Over the past two decades, Michigan and all the tribes have also worked to formalize their relationships through a variety of voluntary agreements in areas of shared interest and mutual commitment, including past agreements concerning water and climate change. The 2002 Government-to-Government Accord executed by Governor Engler and tribal leaders was a landmark agreement establishing a mechanism for consultation, collaboration and dialogue and continues to serve as the basis for a working relationship on a wide range of water issues.

Exploitation of native fisheries, wildlife and forests during Michigan's emergence as the manufacturing center of the nation created great wealth and a high quality of life, but also devastated native fish populations, impacted water quality and left a complex and costly legacy of contamination. Federal, state, tribal and local regulation and restoration programs have made progress in addressing this legacy in many communities. These programs have been instrumental in restoring and ensuring drinkable, swimmable and fishable waters. They include progress under Michigan's Natural Resource and Environmental Protection Act, Safe Drinking Water Act, the federal Clean Water Act and cleanup statutes such as the Environmental Remediation and Leaking Underground Storage Tank Act. In addition to these efforts, recent investments by the federal government through the Great Lakes Restoration Initiative have accelerated efforts to clean up and restore our water resources and fish and wildlife populations, and to improve quality of life in many communities; however, there is more work to be done.

Government-to-government relationships, statutes, regulations and management programs all play a critical and complementary role to the actions recommended in the Water Strategy. There are many successful examples of collaboration and management of our shared waters.

Driving progress toward the goals and the outcomes will depend on harnessing this complex framework of governance, institutions and regulations to continue to build durable relationships and collaboration around common interests. A long-term strategy built upon local, state, federal, tribal and international collaboration that involves continued learning, open dialogue and adaptive management is critical to achieving improved water quality, sustainable groundwater resources and ensuring proper management of these shared resources.

Strategic Actions

The Water Strategy charts a course by providing recommendations and identifying strategic actions to:

Inspire Stewardship for Clean Water

Most importantly, Michigan residents need greater opportunities to learn about water. Michigan is surrounded by 20 percent of the world's fresh surface water, and with that comes a deep ethical obligation to be good and thoughtful stewards of this global treasure. A shared water ethic will guide Michigan into the future and ensure that our children and future generations will have the same or better quality of life than we have today. The durability of this Strategy and ensuring the health of our water resources for generations to come depends on creating a culture of stewardship through lifelong education about water.

Protect and Restore Aquatic Ecosystems

Michigan needs more integrated, holistic approaches to managing water on and across the landscape, including groundwater, which support healthy ecological systems and hydrologic integrity at the watershed scale.

Create Vibrant Waterfronts

Michigan needs an emphasis on water resources as assets in state, regional and community planning efforts to create vibrant and sustainable communities, a robust recreation and tourism industry and a thriving environment and economy.

Support Water-Based Recreation

Michigan needs to create greater opportunity for access to water resources through water trails and appropriate public access.

Promote Water-Based Economies

Michigan needs to collectively build robust multi-sector and multidisciplinary public-private partnerships between business, industry, academia, private capital and government. These partnerships will link ideation; invention and innovation; research and development; capital investment and end users. This approach will bring technologies to the market to better manage and solve water challenges in Michigan and across the globe. Directed research and development to address specific water challenges should provide the basis for forming a new paradigm of collaboration.

Ensure Clean and Safe Waters

Michigan needs to protect and restore water quality to ensure ecosystem function and support current and future human uses of Michigan's surface and groundwater resources.

Invest in Water Infrastructure

Greater and consistent investments are needed in water-related infrastructure improvements to address aging and deteriorating systems that are causing water quality issues and public health concerns. Michigan needs to make investments in water infrastructure systems to realize the benefits they provide, including delivery of safe drinking water, management of stormwater and wastewater, enhanced recreational opportunities and healthy ecosystems and economies.

Monitor Water Systems

Michigan needs to develop and fund a coordinated, long-term monitoring strategy to provide baseline and trend information about surface and groundwater quality and quantity. This information is necessary to base decisions and best direct actions and future investments to support healthy people, ecosystems, communities and economies.

Build Governance Tools

Michigan needs to build new models of governance at the local and regional level to address increasingly complex and intractable problems facing Michigan's water resources. Implementation efforts will require not just state agencies, but a wide array of individuals, organizations, businesses, industries and tribal and local governments across the state to continue to build on this multi-governmental and stakeholder-collaborative approach.

We call on all people of Michigan to be thoughtful and engaged stewards of our water resources.

Water Strategy Framework

The Water Strategy is organized around nine goals and outcomes designed to ensure the viability and sustainability of Michigan's water resources over time; placing Michigan on the path to achieving its water vision in a way that builds economic capacity while sustaining ecological integrity of this crucial resource for future generations.

The Water Strategy includes a series of recommendations that are a set of interconnected ideas to drive a new relationship between Michigan's communities, governments and residents to solve complex water challenges and create greater opportunities for economic and social well-being. The recommendations are designed to drive performance and behavior change, address barriers and contribute toward achieving the desired outcomes. The ability to achieve the stated goals and outcomes will require both the implementation of recommendations in the Strategy and continued implementation of the entire suite of existing water-related programs and initiatives underway at the state, regional and local level as well as across the Great Lakes Basin.

The Strategy includes recommendations paired with lead actor(s) charged with implementation and an implementation metric to measure progress toward accomplishing the recommendation. A wide host of actors and agents across the state and region, including governments, tribal nations, nonprofits, academia, industry, businesses, individuals, as well as local and regional philanthropies will need to be involved. Therefore, the Water Strategy is not a specific action plan only for government, though there are many actions that government can and should take. Rather, it is a strategy for all people of Michigan, believing that together, we can have a positive impact on the future of the State.

The Strategy includes measures of success intended to examine system response over time as a result of the collective impact of implementation of the Water Strategy recommendations and other efforts already underway by state, federal, tribal and local governments and partners to rebuild healthy aquatic systems, clean water and vibrant economies. Achieving success will require integrating planning strategies for water resources with local units of government; unifying plans between the state, regions and local units of governments and collaborating with stakeholders. Additionally, success will require an integrated process for adapting to new science and understanding of complex issues, evaluating progress, and making course corrections necessary to achieve outcomes.

Part I

Inspire Stewardship for Clean Water

Protect and Restore Aquatic Ecosystems

INSPIRE

stewardship for clean water

Stewardship is one of the most important aspects of the Water Strategy because it forms the backbone of use and enjoyment of water for generations to come. Stewardship is about supporting and maintaining what we hold dear to create valued legacy and heritage. Purposefully building stewardship for water resources requires coupling the desire for high-quality water resources with a sense of care for the water systems that provide them. Throughout the development of the Strategy, Michiganders have consistently said they care deeply about the Great Lakes, about their rivers and inland lakes, about groundwater and drinking water and water in general. This connection to place and an understanding of the context of water in communities comes from a lifelong appreciation and caring for water.

Stewardship is driven by personal values, culture and experiences, and supported through our knowledge of freshwater systems and understanding our influence on them. It is important to understand that we live in a hydrologically connected system. The Great Lakes and their watersheds (including lakes, rivers, streams and groundwater) are an integral part of the water cycle whose waterways are connected all the way to the Gulf of St. Lawrence and ultimately to the ocean.

Building stewardship for water resources requires both knowledge of freshwater systems and an understanding of their value. Personal experiences and storytelling grow connections to that value. For example, wetlands provide people with duck habitat for hunting; groundwater systems give us water to drink from; rivers provide places to canoe, fish or birdwatch. We irrigate the orchards, vineyards and fields that fill our plates and we enjoy the pure wonder of a sunset at the lakeside. All give people tangible reasons to value water resources and use them with care.

Key drivers of stewardship of water resources include water literacy, place-based education, personal experience, volunteerism and community engagement and community-based philanthropy.

Improve Water Literacy and Use of Place-Based Education

Michigan is blessed with abundant water resources, yet many citizens lack a basic understanding of fundamental water literacy principles. In recent surveys, in some counties in the State, over 60% of the people in those counties did not realize that they lived within a watershed. While the term "watershed" may not be as familiar to some - the fact remains that there is a distinct lack of understanding about water, water cycles and the overall connectivity of water.

Goal

Michigan citizens are stewards of clean water and healthy aquatic ecosystems

Outcome

Individuals and communities understand their responsibility for and make informed and responsible decisions regarding water resources

Measures of Success

- Increase the number of citizens with knowledge and understanding of water literacy principles.
- Michigan citizens support funding for water and implementation of the Water Strategy.

The durability of this Water Strategy and the future health and condition of Michigan's water resources many generations from now will depend on creating a system of life-long learning about water for all ages. The key audiences include K-16 students and educators, researchers, citizens, businesses, natural resource managers, city planners and legislators.

Integrating freshwater systems into place-based educational experiences is critical to building literacy and stewardship for Michigan's water resources. Place-based education uses the key aspects and elements of local community and the local environment as a starting point for teaching and learning, emphasizes hands-on, inquiry-based, real-world experiences, and, ideally, involves direct collaboration with community partners. Learning about the world in the context of where you live through place-based education and experience creates a learning environment that engages learners in a more meaningful way. The benefits of place-based education include powerful learning, a healthy, supportive school culture, sustainable partnerships between schools and communities, a greater appreciation of the environment and more frequent and effective acts of stewardship.

Substantial work in this area is underway through independent programs and projects like the Great Lakes Stewardship Initiative (supported through the Great Lakes Fisheries Trust,) Water-On-The-Go program at Cranbrook's Institute of Science, General Motors' Global Rivers Environmental Education Network (GREEN) and the Saginaw Chippewa Indian Tribe of Michigan Environmental Education Program, working at the grassroots level in communities and watersheds across the state.

Despite these efforts, many residents across the state still lack basic knowledge about watersheds and how our water resources are affected directly by the decisions and actions of people. It is imperative that understanding of individual and collective actions needed to effectively conserve and manage water resources are understood. Existing outreach programs bring a necessary focus on water into classrooms but are not enough. As the Great Lakes state, Michigan must have a unified set of water literacy principles as part of its K-12 curriculum standards that address these deficiencies. Michigan must build a durable, connected and sustainable curriculum about water across all the grades. Educators need to be well-versed not only in critical environmental science content but how that content is most effectively taught to students. Educators need ongoing professional development to support their efforts in this arena.

Federal and state agencies govern formal K-12 education, help guide curriculum content and use testing instruments to measure knowledge retention. Educational leaders have made some efforts to build water literacy into the grade school curriculum. For instance, the K-4 science standards focus on life requirements, life cycles, and water and water movement. These content expectations span four scientific disciplines: science processes, physical science, life science and earth science. One significant challenge to increasing water literacy overall is the absence of a common focus among state government, universities, colleges, nongovernmental organizations, businesses and foundations. Collectively, Michiganders need to agree on common goals to improve water literacy, including lifelong education. A water focus, one strongly tied to STEM education, built over a child's educational life and into adulthood, can serve as the basis for place-based learning and scientific knowledge.

Ample coursework and curriculum about water resources is already available, but unlike other critical areas of knowledge, is not required of all students

nor is it linked to their place or community. The Great Lakes state should have a water-based curriculum linked to STEM concepts and the life sciences should be a basic requirement throughout the science curriculum, beginning in kindergarten. Knowledge of local water systems, like watersheds, flow, rivers and discharges, provide a relevant and place-based context for learning. Weaving water into school curricula is crucial to fostering future water stewards, leaders and decision makers.

Increase Volunteerism and Community Engagement

One key aspect of stewardship within a community is whether residents are willing and able to volunteer their time to better their own local water resources. Examples include maintenance of healthy rivers through activities such as river cleanup days, invasive species management along the shore, and water conservation. Communities that exhibit strong stewardship characteristics have more individuals and groups engaged with the community and also tend to financially support measures that drive good management practices such as environmental cleanups and funding programs. The focus on building stewardship and care can translate directly into heightened engagement and long-term benefits to the community, the state and water resources.

Michigan has a diverse and passionate portfolio of nonprofit organizations including some of the oldest organizations in the country working to increase volunteerism and community engagement in natural resource management and conservation. Conservation and watershed-based organizations, as well as local volunteer programs such as the Michigan Clean Water Corps (MiCorps) program, play an important role in supporting and contributing to state water management programs and achieving long-term outcomes.

Implementation of stewardship activities should be coordinated with other grassroots efforts and must address social and cultural gaps in access and opportunities to experience water. Studies have shown that people are more likely to engage in stewardship of natural resources if they have had an opportunity to personally experience nature. Long-term sustainable funding mechanisms are needed to continue this important work at the grassroots and community-based level.

Studies show that people are more likely to engage in stewardship activities if they have had an opportunity to experience nature

Community-based philanthropy

Another act of stewardship within a community, similar to volunteerism, is philanthropy and giving. How people choose to spend their money is a deep reflection of what they value. Every county in Michigan is covered by a community foundation in some fashion, and many of these have education funds, environmental funds and other funds that focus on water and environmental issues. There are also a myriad large and small family foundations, corporate foundations and independent foundations. In addition to more formal philanthropic structures, there are vast networks of nonprofit organizations supported through private giving. The Foundation Center of New York reports that grant making for environmental and animal welfare issues was $56.8 million in Michigan from 2011-12. This category consistently makes up six to seven percent of total grant making for foundations that make grants of at least $10,000.

Organized philanthropy in the state join together periodically on environmental issues through the Council of Michigan Foundations in issue-specific groups, such as the Green and Blue Network, and the Land Use Funders. There are no readily available statistics on the amount individuals give to support environmental and water-related interests, but individual philanthropy combined with foundation philanthropy is in excess of $60 million annually for the state.

Local and individual philanthropy can have a direct impact on a community's ability to achieve Water Strategy goals. Further alignment is needed amongst private foundations and community based philanthropy to support key elements of the Strategy.

Goal: Michigan Citizens are Stewards of Clean Water and Healthy Aquatic Ecosystems			
Outcome: Individuals and Communities Understand Their Responsibility for and make Informed and Responsible Decisions Regarding Water Resources			
#	**Recommendation**	**Implementation Metric**	**Lead Actor**
1	Integrate water literacy principles into place-based education and state of Michigan curriculum standards tied to Science, Technology, Engineering and Math (STEM) across all grade levels and coordinate, deliver and support ongoing freshwater-focused professional development for Michigan K-12 educators.	By 2017, develop a strategy to integrate freshwater literacy principles into place-based education, state curriculum standards and professional development for K-12 educators.	Department of Education, MDEQ, MDNR and State Board of Education, Non-governmental organizations (NGOs), Local units of government, Public and private educational institutions, Watershed councils
2	The State, working with stakeholders, will develop a public outreach campaign that highlights stewardship practices and encourages actions that sustain water resources.	By 2017, develop and implement a communication strategy focused on connecting economic, environmental, social and cultural values to Water Strategy outcomes. Utilize survey tools and data collected to assess behaviors and attitudes toward Michigan's water resources to assess changes over time to measure: • Michigan's residents willingness to fund water quality infrastructure • Community's connection to local water assets • Michigan's residents knowledge of and affinity for local waters • Volunteerism and local philanthropy that support a community's vision for water and water-related assets.	MDNR, MDEQ, MTED, Local units of government, NGOs
3	Work with existing volunteer, community-based and statewide conservation organizations to promote and expand opportunities to engage citizen volunteers to achieve the Water Strategy goals and outcomes, such as the Michigan Clean Water Corps program.	By 2017, develop a list of participants and define engagement levels. Track progress toward increasing engagement levels. By 2018, secure long-term funding for the MiCorps program and evaluate opportunities to expand the scope of monitoring activities.	MDEQ, MDNR, NGOs
4	Work with the Council of Michigan Foundations to assess the potential for further alignment of strategic funding with philanthropy towards implementation of Water Strategy goals.	By 2017, convene, through the Council of Michigan Foundations, a funder's summit for Community Foundations and Donor Advised Fund managers. Assess the potential for a pooled Great Lakes social equity fund, supported by private philanthropy that would support Great Lakes restoration and management.	MDEQ, Council of Michigan Foundations

PROTECT

and restore aquatic ecosystems

Healthy, functional ecosystems purify air and water, provide habitat for fish and wildlife, serve as buffers from flooding and support natural resource-based economies. All long-term, sustainable uses of water depend on intact ecological and hydrologic systems. Ecosystems link living organisms with the non-living components of their environment like the water, soil and air. While the Water Strategy focuses on the water component of ecosystems, it recognizes that changes in the make-up or distribution of organisms and disturbances on the land or in the air also impact water, and that hydrologic management across the landscape directly affects those systems.

For example, the introduction of aquatic invasive species (AIS) in the Great Lakes region has been a major challenge to the resiliency and diversity of aquatic ecosystems. The presence of invasive species combined with nutrient runoff can have devastating impacts on fisheries and other aquatic life, disrupt the ecology of lakes and streams, and contribute to nuisance aquatic plant growth and algae blooms. In a few areas of the Great Lakes, nuisance algal growths have been associated with botulism outbreaks, "muck" (organic debris), washing up on beaches and impacts to drinking water systems. Some nuisance algal growths have also been characterized as toxic, harmful algal blooms (HABs).

The practice of moving water off the landscape as quickly as possible has resulted in both positive and negative consequences. Since the mid-1800s, Michigan has developed more than 35,000 miles of public drains, serving more than 17 million acres of agricultural and urban lands and roadways. These drains provide benefits by removing excess stormwater; preventing damage from flooding; improving soil productivity and enabling residential and commercial development. However, these extensive drainage systems were designed without consideration of the long-term consequences of modifying natural hydrology.

In addition, other hydrologic modifications like storm drains and extensive impervious surfaces like parking lots, contribute to less infiltration and increased surface water runoff and flow, resulting in increasingly "flashy" streams. These cause stream bank erosion and increase sediment loads, transporting nutrients that impair aquatic life. The excess surface water runoff, combined with sediment and nutrient loading, leads to water quality degradation such as decreased dissolved oxygen and sediment deposition within the stream channels.

Goal

Michigan's aquatic ecosystems are healthy and functional

Outcome

Aquatic systems are resilient and diverse

Measures of Success

- No net loss of primary indicator species such as steelhead, brook trout, sturgeon and lake trout, from baseline levels.
- Natural salmon and trout populations are thriving due to enhanced river connectivity and removal of impediments to migration.
- Reduction in nuisance and harmful blue-green algal blooms.
- Waters of the state meet Water Quality Standards.
- Reduction in annual volume of untreated sewage discharges.
- Reduction in the number of designated use impairments due to wet weather discharges.

These changes in the water quality lead to a decline in the benthic population on which the fish population is dependent, evidenced in recent losses of cold water indicator invertebrates that sustain trout populations.

The loss of infiltration can reduce vital aquifer recharge and reduce base flow to streams. In rural areas, infiltration to deeper depths is interrupted by tile drains designed to conduct water away from fields. These hydrologic changes can pollute receiving waters, impact aquatic life that depends on groundwater-fed streams during summer months and affect human use of groundwater.[4]

Growing conversations in the international community regarding climate change recognize that changing climatic conditions throughout the world are causing social, ecological and economic impacts.

While Michigan's climate future is unclear, climate change can lead to significant impacts to water resources, particularly through the variability and intensity of extreme weather (severe storm events and drought), more rapid runoff, greater flashiness in streams, sediment loadings, pollutants in runoff and flooding events. In the Great Lakes region, variability in precipitation from year-to-year is large. Total annual precipitation has increased in the Great Lakes basin by 4.5 inches from 1915 to 2004, with 4.2 of those inches occurring from 1955 to 2004.[5] Michigan's current infrastructure capacity was not designed to effectively handle increased volume and intensity of extreme weather events, leading to potential challenges in flood management zones and hazard mitigation planning and implementation.

Climate change can also lead to changes in seasonality of significant precipitation, natural community composition, species ranges (including invasive species) and degradation of habitat. Changes in water levels and temperature can impact culturally significant species such as whitefish, sturgeon and wild rice, important for ecological balance, subsistence economies and cultural purposes in tribal communities. Changing climatic conditions will require Michigan to be proactive in its use of adaptive management approaches to water management to mitigate impacts to ecological, economic, social and cultural resources, including designing infrastructure to effectively handle extreme weather events. The Water Strategy focuses on adaptive management approaches to reduce threats to aquatic ecosystems and implementation of watershed-based approaches to restore hydrologic integrity and improve aquatic ecosystem and community resiliency. Holistic watershed-based approaches that slow the movement of water across the landscape; increase infiltration capacity; reduce erosion, sediment, nutrient flow and wastewater discharges; and increase aquifer recharge are needed for long-term preservation of Michigan's hydrology. These approaches are critical to ensure healthy functional ecosystems that wildlife and human populations depend on.

Prevent Introduction of and Manage Aquatic Invasive Species

Since the 1800s, more than 182 nonindigenous aquatic organisms, including animals, plants, bacteria and viruses, have colonized the Great Lakes ecosystem, forever altering its ecology. The introduction of AIS into the Great Lakes and inland waters has caused significant damage to the state's natural resources and beneficial uses by humans.

Detriments include Eurasian water milfoil clogging inland lakes and the devastating effects of sea lamprey on fish communities. In addition, other negative impacts include round gobies eating fish eggs and larvae and serving as a vector for botulism poisoning in wildlife and water fleas snagging fishing lines and changing the zooplankton community. Of particular note, invasive mussels have disrupted the energy flow, nutrient cycling and food web which has altered fish communities and affected top predators in the Great Lakes such as lake trout. The intensive filtering activities of zebra and quagga mussels have greatly increased water clarity, allowing the long filamentous algae known as *Cladophora*, as well as other types of algae, to grow to nuisance levels in areas where it previously did not occur. When *Cladophora* dies and breaks loose, it creates conditions ripe for the production of the botulinum toxin in Great Lakes sediments by creating the very low oxygen conditions required by Type E botulism spores to become active. Type E botulism outbreaks have resulted in fish kills and the death of waterbirds.

Since the 1800s, more than 182 nonindiginous aquatic organisms have made their way to the Great Lakes

Michigan has led the region for decades in focusing on prevention of new introductions and minimizing impacts of established invasive species. To combat the introduction of new AIS and minimize the impacts of established ones, Michigan developed the second state AIS management plan in 1996, later updating it in 2013. It provides a comprehensive strategy outlining new actions and enhancing existing efforts to prevent and control AIS in Michigan waters, including continued support for separation of the Great Lakes and Mississippi watersheds. In addition, the Michigan Department of Natural Resource's Fisheries Division Strategic Plan, Charting the Course: Fisheries Division's Framework for Managing Aquatic Resources, provides specific actions to support healthy aquatic ecosystems and sustainable fish populations. It also provides strategic assessments and tools to inform decision-making. However, more is needed. Long-term mandates for the prevention of new invasive species into the basin will depend on a collaborative approach.

Reduce Occurrence and Impacts of Harmful and Nuisance Algal Blooms

Nuisance algal blooms are increasingly a problem in the Great Lakes and have been documented in some inland waters. Some algal blooms are dominated by blue-green algae also known as cyanobacteria that produce harmful toxins; these blooms are characterized as harmful algal blooms (HABs) based on concentrations of toxins produced. The most common algal toxins are Microcystin, Anatoxin-a, Cylindrospermopsin and Saxitoxin. For example, the toxin Microcystin is produced by the cyanobacteria Microcystis. HABs occur when Microcystin exceeds the World Health Organization's non-drinking water guideline of 20 ug/l or drinking water criteria of 1 ug/l in water bodies with drinking water intakes. However, state agencies will likely adopt new criteria as additional information becomes available.

The presence of these toxins is known to impact human health and can cause closures of drinking water systems and beaches, including a well-publicized HAB in western Lake Erie in 2014 that prompted officials to shut down the drinking water system in Toledo and a few areas in Michigan. Health symptoms commonly associated with algal toxin exposure include nausea, skin rashes, gastro-intestinal distress, numbness and fatigue.[6] These toxins can also kill fish and other aquatic life. The most commonly monitored algal toxin in Michigan is Microcystin; however, MDEQ is evaluating monitoring protocols for other toxins.

Algal blooms are caused by many factors, including excessive inputs of nutrients, usually phosphorus and to a lesser extent nitrogen. Meteorological conditions can also play a role in determining algal bloom severity and seasonal dynamics. For example, the occurrence and duration of extreme weather events, such as heavy rainfall and droughts, may influence the development of algal blooms by intensifying the magnitude and timing of nutrient delivery from the watershed.[7] In addition, changes in the food web caused by the introduction of invasive species can change the way nutrients are partitioned in the environment or change environmental conditions enough to trigger algal blooms. Physical factors affecting water temperature, light penetration and water column mixing may also contribute to create potentially favorable conditions for algal blooms.

One step to combating HABs is to address agricultural point and nonpoint sources of sediment and nutrients that have been identified as a major source of the pollutants in recent western Lake Erie Basin studies conducted in both Michigan and Ohio. These opportunities include promoting changes in the use of phosphorus through mechanisms like the 4R Program (Right Source, Right Rate, Right Time, Right Place), implementation of the Michigan Agriculture Environmental Assurance Program (MAEAP) suite of practices, restoration of grasslands and wetlands, use of vegetative filter strips, use of technologies like precision farming and implementing no-till and conservation tillage techniques to reduce run-off.

The biggest challenge posed is the lack of a comprehensive understanding of the cause of HABs in Michigan's waters. For example, HABs that are capable of producing toxins are not limited to nutrient rich waters and can be found in nutrient poor waters like oligotrophic lakes. It is not possible to tell visually (including via satellite), by taste or by odor whether a bloom is a HAB. Additional work must be done in order for state, federal and local partners to make strategic decisions to determine best possible solutions to address the problem. A strategy to prevent HABs should be developed, involving a broad set of state, federal and local partners and include conducting additional monitoring, data collection and research to improve the understanding of the cause of HABs and inform models and actions to achieve the desired water quality and public health outcomes.

Integrate Water Knowledge into Local Land-Use Planning

Land-use planning is inextricably linked to healthy aquatic ecosystems, a clean and available water supply and protection from natural occurrences that can damage property. In Michigan, decisions about how the land can be used are made at the local level through master planning and zoning ordinances. Communities use these tools to plan and guide the character of the community and influence the local economy.

However, local community and economic development planning is based on political boundaries and jurisdictions, not along watershed boundaries. To be effective, these planning tools should consider activities that adversely affect water quality and quantity, such as extreme weather events, throughout their watershed and incorporate best management practices into transportation, infrastructure and zoning regulations

and other community development planning to minimize impacts on local water resources. In addition, planning across municipal boundaries, sharing of information and services at the watershed scale is needed to achieve desired water quality and quantity outcomes.

Build Resiliency into Riparian Systems

One of the most direct ways to positively influence water quality and aquatic habitat is to restore, create and improve riparian areas. Riparian areas, or land area adjacent to a stream or lake, provide critical ecosystem services and benefits for lakes and rivers, including:

- Reducing runoff by acting as a barrier and protecting against erosion and nonpoint source pollution
- Absorbing contaminants
- Moderating water temperature through shading
- Serving as a greenway corridor for birds, mammals, amphibians and reptiles
- Contributing leaves, woody debris and other organic matter as foundation for the food web and providing in-stream habitat for fish and other aquatic organisms
- Providing pleasing recreational corridors or viewscapes

Accelerated erosion and sedimentation problems occur in rivers and lakes throughout Michigan as a result of lack of riparian management. Hardening of the riparian zones, lack of shade due to deforestation and a lack of continuity in riparian areas all contribute to increased stream temperatures, resulting in declines of fish and wildlife habitat. In some watersheds, lack of upstream riparian filter strips or buffers results in the need for increased downstream dredging at river mouths for boat access and international shipping. Upstream riparian management of soils is an essential tool that can reduce the quantity of sediments and also improve quality of sediment. Sediment that is higher in quality will improve opportunities for beneficial uses of dredged materials and reduce the need for costly dredge disposal.

Currently, a patchwork of regulatory and non-regulatory approaches are used to manage riparian zones, including watershed management plans, best management practices, state programs and landowner incentives. The success of many voluntary programs, however, is contingent on a well-informed and cooperative landowner. To maximize benefits, a more holistic watershed approach is needed for riparian area management. Taking a broad approach that considers the hydrologic function upstream and downstream for riparian management can have comprehensive impacts on aquatic ecosystems, international shipping, and river recreation. In addition, the interest in waterfront development combined with the need to decrease management costs (dredging) and reduce impacts of extreme weather events provides an opportunity to better define science-based actions and consciously manage riparian areas throughout Michigan.

Protect and Restore Wetland Function

Wetlands are among the most productive ecosystems and play a vital role in recreation, tourism and the economy. Michigan is home to a broad variety of wetland types, including deciduous swamps, wet meadows, emergent marshes, conifer swamps, lake plain prairies, shrub-scrub swamps, vernal pools, fens and bogs. These wetlands are a significant factor in the health and existence of other natural resources of the state and their hydrologic capacity provides flood control. They provide nesting, breeding and cover areas for many types of aquatic and terrestrial wildlife. They recharge our groundwater supplies and serve as natural filters for pollutants and sediment. Wetlands habitats also include diverse plant communities that have ecological, social, cultural and economic value such as wild rice.

Approximately 40 percent of Michigan's wetlands have been lost over time due to development and land use changes. The State has established a long-term goal of restoring 500,000 acres of wetlands. Partnerships are needed to develop innovative strategies to protect existing wetlands, and enhance wetland restoration and green infrastructure efforts that contribute to improving resiliency and diversity of aquatic resources. This is critical to sustaining Michigan's aquatic ecosystems and our urban and rural communities. Native wetland plant species such as the two native

species of wild rice (*Zizania spp.*), tend to grow in high-quality wetland areas and may be looked upon as an indicator species of climate change and water quality. Some species are listed as threatened. Fish and wildlife utilize wild rice beds and other native vegetation for spawning, brood rearing and as an important food source. Wild rice was once present throughout the state in lakes, bays and river systems. However, threats from development and invasive species like *Phragmites* have competed with historic and restored stands of wild rice.

Wild rice is an integral part of Michigan's Indian heritage. Michigan tribes have expressed the significance of wild rice to their spiritual, historical, cultural, ceremonial, social values and relationships, food systems and economies. The tribes view themselves as caretakers, responsible for protecting wild rice. Some Michigan tribes initiated rice restoration efforts beginning in the late 1980s, while other tribes have joined this effort more recently with additional restoration projects. Successfully restored sites would benefit from increased public recognition and an adequate level of protection from threats like invasive species and other impacts.

To address both the ecological and tribal importance of wild rice, effective coordination, planning and implementation for control of threats such as invasive species, along with adequate protection within wetland habitats must be given a high priority from state, federal and tribal governments.

Restore Hydrologic Connectivity

Michigan has more than 2,500 dams, the majority of which are nearing or have exceeded their design life. Federal, state and local governments as well as conservation organizations are removing dams that provide little to no natural resource value to reconnect streams and rivers. However, challenges exist including ownership questions (74 percent of dams are privately owned), financial burdens, social views on dam removal and value of impoundments behind dams. Additionally, careful considerations must be made to prevent the upstream movement of unwanted invasive species and downstream movement of contaminated sediment trapped behind dams.

Despite these challenges, federal, state and locally funded efforts have achieved progress in restoring connectivity. As examples, dam removal and river restoration projects are re-envisioning the role of the Boardman, Cass and Huron Rivers. These restoration efforts create greater opportunity for recreation and economic development by connecting water and place within communities.

Manage Groundwater Withdrawals

Michigan's water resources are vitally important for agricultural production, irrigation, drinking water, electric utilities, mining, manufacturing and water supply to lakes and streams that support valuable fish, waterfowl and wildlife populations. Despite the large volumes of surface and groundwater in Michigan – more than one quadrillion gallons by some estimates – there is growing concern about its use and about groundwater withdrawal effects on environmental function and integrity. Groundwater use and value is increasing, and the state must invest in the information and decision systems to realize groundwater's full value, promote its wise use and protect its hydrological and ecological integrity.

Groundwater is an important resource for commercial, industrial, domestic and public supply purposes. Most of Michigan's large groundwater withdrawals are for agricultural irrigation. More than 2,500 high-capacity irrigation groundwater wells have been registered for installation during the past four years. These wells greatly enhance economic development (in particular agricultural productivity), ensure against drought conditions and augment high-value crop production. However, as farmers and others develop more high-capacity irrigation wells, the odds of interfering with nearby domestic wells and surface water systems like rivers and lakes also increase. Responsible management of groundwater recharge is an issue of growing importance for ensuring sustainable groundwater resources and supporting demands for agriculture and other human uses.

Michigan has developed the Michigan's Water Withdrawal Assessment Tool to help the State manage groundwater withdrawals. A new or increased high-capacity well must be evaluated using the groundwater tool before installation. The Groundwater Tool is specifically designed to assess the likelihood

of an adverse impact of withdrawals on nearby streams, rivers and fish communities. Michigan's Water Use Advisory Council, established by MDEQ in 2012, completed its assessment of Michigan's water management framework, including the Water Withdrawal Assessment Tool, and issued a series of recommendations to MDEQ in December 2014. The MDEQ has since reviewed and assessed the recommendations and developed an implementation plan to address priority recommendations. The Water Withdrawal Tool creates publicly (and easily) accessible streamflow and groundwater elevation data, along with the total quantity of permitted withdrawals. The development of a robust and effective water management program for the state will be an ongoing, iterative process and the insights and recommendations such as the ones in the Council's report will continue to help shape the development of that process.

Improve Water Management in Urban Landscapes

In urban areas, impervious surfaces like roads, buildings and parking lots prevent rainfall from penetrating the soil. As natural vegetation is removed and these surfaces increase, the amount of evapotranspiration and groundwater recharge decreases. This causes increased runoff, stream channel erosion, buried river bottoms due to silt and sediment, reduced or lost habitat and aquatic species decline. Aging infrastructure and ill-managed or improperly managed stormwater runoff also contributes to sewer overflows, affecting water quality, ecological systems, creating human health risks and negatively impacting the enjoyment of water resources.

As municipalities struggle to address aging infrastructure and capacity issues, opportunities exist to transition away from grey to green infrastructure. Green infrastructure can increase a community's resiliency to severe weather events by increasing infiltration and absorption of water. This reduces flooding risk, decreases surface runoff into lakes and streams and reduces impacts of aging systems. Many communities are considering developing green infrastructure such as wetlands, green spaces and buffer strips, as well as man-made infrastructure like rain gardens and bioswales. In addition, incorporating green infrastructure into transportation projects and placemaking initiatives can improve stormwater management and reduce pressure on existing water infrastructure. Overcoming barriers to green infrastructure such as limited funding mechanisms, regulatory and permitting requirements, institutional and organizational capacity and lack of understanding of design and maintenance requirements will be necessary to improve water management and address stormwater.

Improve Water Management in Rural Landscapes

Michigan's $5.5 billion drainage infrastructure sustains some of the most productive agricultural land in the world and became a key component in developing land for residential, commercial, industrial and transportation purposes. However, the historical land changes that led to this productivity, such as the draining of wetlands, dredging and straightening of rivers and streams, converting streams to drains and deforestation have resulted in degraded water quality and aquatic ecosystems.

The agricultural community understands the importance of water resource conservation and is continuously considering new methods for managing water, including restoring hydrology, enhancing soil's capacity to retain and infiltrate rainfall and allowing for aquifer recharge. New science and technological advancements are also impacting agricultural water management with research in areas such as identifying the most efficient irrigation timing and amounts for crops in dry weather conditions, water reuse for irrigation and reducing nutrient loss via tile lines.

The federal Agriculture Act of 2014 commonly known as the Farm Bill is also providing resources to enhance conservation practice implementation in Michigan to address nutrients and sediment. Other initiatives are underway such as the newly formed regional and community-led Healthy Waters Working Farms initiative that combines conservation practices and farmland preservation to keep Michigan's rivers and lakes clean while keeping the best farmland working.

It is critical that governments, academia and industry collaborate to develop new tools, processes and systems to help local officials, landowners, agricultural producers and others who impact the rural landscape to take actions to improve water resources. The Natural Resource Working Group has concluded that the establishment of collaborative partnerships to support learning and adaptation is needed to foster community-based natural resource management. Engaging the rural community as a whole in deciding what behaviors should change to maintain and improve water quality and determine what actions would be necessary to encourage behavior change are necessary to drive performance toward desired outcomes on the landscape.

Goal: Michigan's Aquatic Ecosystems are Healthy and Functional.			
Outcome: Aquatic Ecosystems are Resilent and Diverse.			
#	**Recommendation**	**Implementation Metric**	**Lead Actor**
1	Prevent the introduction of new aquatic invasive species and control existing populations of AIS in accordance with the Michigan Aquatic Invasive Species Management Plan	By 2020, studies have been completed on a system of control points in the Chicago Area Waterways System to prevent the interbasin transfer of aquaic invasive species. By 2022, construction has been initiated at the Brandon Road Lock and Dam in Joliet, Illinois to prevent further upstream movement of invasive carp.	State and federal agencies, Tribal governments, Nongovernmental organizations (NGOs), Local units of governments, and individuals.
2	Work with other Great Lakes states and provinces to harmonize aquatic invasive species prevention, early detection processes and response actions across the Great Lakes region.	By 2017, implement a pilot project with Ontario and interested states to evaluate and pursue areas of harmonization.	State agencies, Province of Ontario
3	Accelerate research and solutions to identify mechanisms of food web disruption and changes of nutrient flows in the Great Lakes with a focus on the effects of invasive species.	By 2017, a minimum of three new research projects will be established for the purposes of evaluating nutrient shifts in Great Lakes food webs to help focus appropriate management, social, and economic responses.	Universities
4	Develop a comprehensive strategy to prevent nuisance and harmful blue green algal blooms.	By 2017, develop a strategy to prevent harmful algal blooms and HABs based on desired outcomes.	MDEQ, MDARD, MDHHS, Local health departments
5	Achieve a 40% phosphorus reduction in the western Lake Erie basin.	Develop and execute implementation plans to achieve a reduction in phosphorus loads from the Western Lake Erie Basin of 20% by 2020 and 40% by 2025.	MDEQ, MDARD
6	Develop harmful algal toxin water quality criteria and implement a real-time monitoring strategy for Michigan's Great Lakes drinking water intakes and public recreation locations threatened by harmful algae.	By 2020, increase by 20% the number of people served by drinking water suppliers using surface water sources with real-time monitoring equipment installed to provide early warning of potential public health threats. By 2020, develop harmful algal toxin assessment criteria. By 2020, implement a real-time monitoring strategy for Michigan's Great Lakes drinking water intakes and public recreation locations threatened by HABs.	MDEQ, MDHHS

#	Recommendation	Implementation Metric	Lead Actor
7	Support the development of a national drinking water advisory or action level target for harmful algal toxins.	Work with federal agencies to develop a national advisory target.	MDEQ, MDHHS
8	Incorporate planning for wet weather extremes, droughts and increased seasonal variability of precipitation into state, regional and community planning and infrastructure design to mitigate impacts to ecological, economic, social and cultural resources.	Best management practices are reviewed every five years and updated (if necessary) to reflect climatic changes such as changes in rainfall frequency, duration or intensity.	State, Regional governmental entities, Communities, NGOs
9	Provide technical assistance and develop technical tools and training programs for communities, local officials and stakeholders to inform and improve their water literacy and help them integrate water impacts into local land-use planning and decisions.	By 2020, develop a public official water literacy measurement tool. By 2020, develop a training module for local elected officials and decision-makers on the connection between land-use planning and zoning and the siting and approval of new projects. By 2020, develop a training module for local elected officials and decision-makers on the merits and benefits of asset management planning.	Universities, Regional government and planning organizations, NGOs, MDEQ
10	Develop tools and guidance related to shoreline and riparian ecology and management and provide necessary technical support and training to municipalities, watershed-based organizations and landowners to achieve full benefits of riparian areas.	By 2020, develop a baseline for the current research and educational capacities. • Coordinate to pinpoint areas of capacity expansion. • Develop tools, guidance and training on best practices. • Determine need to update guidance and training materials.	MDNR, MDEQ, NGOs, Watershed organizations, Michigan Natural Shoreline Partnership
11	The State, working with tribal governments and stakeholders, will establish new partnerships to develop innovative strategies to enhance wetland restoration and green infrastructure efforts in Michigan. The tribes will work with the State to elevate the recognition, protection and restoration of native wild rice stands throughout the state.	By 2018, state agencies and stakeholders will work together to establish partnerships that develop innovative strategies to enhance wetland restoration and green infrastructure efforts. The tribes will work with the State to elevate the recognition, protection and restoration of native wild rice stands throughout the State.	MDEQ, MDNR, MDARD, Tribal governments, Local units of government, NGOs
12	Remove or improve dams that are no longer safe or ecologically, economically or socially viable to protect public safety and create healthy, connected aquatic systems.	By 2020, address all dams classified by MDEQ as high hazard facilities in unsatisfactory condition.	MDEQ, MDNR, Local communities, Dam owners

#	Recommendation	Implementation Metric	Lead Actor
13	Focus river and stream restoration efforts on addressing small hydrological impediments like culverts to enhance connectivity and restore stream stability.	By 2020, increase the number of small hydrologic impediments that are restored over a baseline established in 2016.	NGOs, Tribal governments and local units of governments
14	Refine and improve the water withdrawal assessment process and model to ensure sustainable use of water resources and that high priority is given to incorporating existing and new data to better represent local and regional water resources and surface water/groundwater interactions.	By 2020, initiate priority Water Use Advisory Council recommendations as identified in the implementation plan.	MDEQ, MDNR, MDARD
15	Provide technical and financial support to communities and their partners to plan and implement green infrastructure techniques and low-impact development while preserving natural spaces that contribute to water quality, including application of these techniques in the design of new developments, redevelopments and road projects to ensure stormwater management, improved hydrology and overall water quality.	By 2020, increase the number of attendees to green infrastructure conferences, applications for projects, amount of grant dollars awarded to projects incorporating green infrastructure or low-impact development, and number of programs incentivizing green infrastructure projects and the number of Michigan communities that are recognized for green infrastructure projects and strategies over a baseline established in 2016.	MDEQ, MDOT, MDNR, Michigan State Housing Development Authority, MEDC
16	Modernize road and highway planning and infrastructure and integrate with watershed planning to effectively accommodate storm water runoff and infiltration needs, thereby reducing the costs and impacts of flooding.	By 2020, increase the number of Michigan's new road and highway projects designed to better accommodate storm water runoff and infiltration needs over a baseline established in 2016.	MDOT, Local road and highway commissions, Watershed and regional planning organizations
17	Enhance financial and technical support of local stakeholder efforts to develop and implement watershed management plans to restore impaired waters, protect high quality waters and develop and utilize local water resource assets.	By 2018, increase the number of grants, training and educational opportunities that support the development and implementation of watershed management plans over a baseline established in 2016.	MDEQ

#	Recommendation	Implementation Metric	Lead Actor
18	Use existing authority to work with local units of government with storm water discharge or storm water-related hydrologic impairments in their waterways to establish Phase II storm water plans for impaired water bodies.	By 2020, increase the number of water bodies with storm water plans in place to address designated use impairments caused by storm water discharges and hydrologic impairments over a baseline established in 2016.	MDEQ, MDNR
19	Eliminate impairments in priority watersheds that have degraded water quality and/ or aquatic ecosystems due to nutrient runoff and soil erosion. Engage landowners through a collaborative and adaptive community-based natural resource management process to identify local actions to change behaviors and develop solutions to achieve desired outcomes within established timeframes.	By 2018, identify priority watersheds. Develop performance standards to cover statewide land-use activities. Agricultural land-use will directly follow MAEAP guidelines and participation criteria to remain consistent with the state's recent efforts. By 2018, develop Regional Action Teams (RATS) through MAEAP with protocols for working with landowners. Educate collaborative teams on existing regulations and enforcement mechanisms allowed in their regions. Through RATS, identify additional required actions if demonstrable outcomes are not achieved within established timeframes.	MDEQ, MDARD

Part II

Create Vibrant Waterfronts

Support Water-Based Recreation

Promote Water-Based Economies

CREATE

vibrant waterfronts

Michigan's abundant water resources, including its coasts, ports and harbors, rivers, lakes and streams, make many communities desirable places to live, work and play. Historically, Michigan's waterfronts supported industries such as shipbuilding, power production, lumber yards, tanneries and chemical production. Many communities developed commercial centers with their backs to the water. As industries abandoned the waterfront, many became eyesores and the public's connection to water as a community asset was lost.

Initiatives such as the federal Clean Water Act, corresponding state water regulations, strong local champions, and recent investments from the GLRI have turned polluted waters into thriving systems. As a result, communities began to rediscover their waterfronts and reimage their communities focusing on their water resources. Water is once again playing a pivotal role in transforming communities' economies and is reflected in their values and desires.

Integrate Water Assets into All Planning Initiatives

Including water assets in community development reestablishes the connection between citizens and the outdoors, building a sense of place and improving overall quality of life. The way people relate to water in their community can drive ecological, economic and social outcomes. A stronger understanding of this relationship is needed to assist communities with economic and community development through proper land-use planning and form-based design.

By understanding this relationship, communities can more effectively integrate water as a strategic asset, maximize economic and social capital, strengthen the relationship people have to water, and avoid potential challenges with conflicting or unaligned policies or actions. Ultimately, creating greater opportunities to interact with local water resources can help foster a water conservation ethic in individuals and the community.

Research shows people are willing to pay more to locate to areas with access to clean water and good environmental quality. Residents drawn to these environmentally attractive places help communities create more wealth and more jobs. Studies by the Brookings Institution and Grand Valley State University show a 3-to-1 and 6.6-to-1 return, respectively, on investments in restoring water quality and shorelines in the form of increased property values and local economic development.[1]

Goal

Michigan communities use water as a strategic asset for community and economic development

Outcome

Economic and community development plans and efforts fully leverage water assets to create great places to live, work and play

Measure of Success

- All community and economic development plans integrate water resource assets.

Foster Community Leadership to Reconnect Communities to Water

Fully leveraging water assets will require fostering community leadership and local champions. These leaders, both inside and outside of government, should fashion a comprehensive, community-informed vision, strategy and implementation plan for stitching water into the fabric of their communities. The strategy and implementation plan must balance economic opportunities, environmental protection and human well-being to ensure sustainability. Communities such as Alpena have embraced their maritime heritage with partnerships between the community and the National Oceanic and Atmospheric Administration's Thunder Bay Sanctuary. Grand Rapids is reimagining its relationship with the Grand River through its plans to reinstate its namesake rapids. The magnificent Detroit River transformation has been developing for nearly a decade under the leadership of the Detroit Riverfront Conservancy. Many other communities including Marquette, Flint, Kalamazoo, Battle Creek, Traverse City, Boyne City and Petoskey have also refocused the role that their waterfronts play in their community's vibrancy. Their experiences provide powerful case studies to share with other Michigan communities.

Create Sustainable Commercial Ports and Harbors

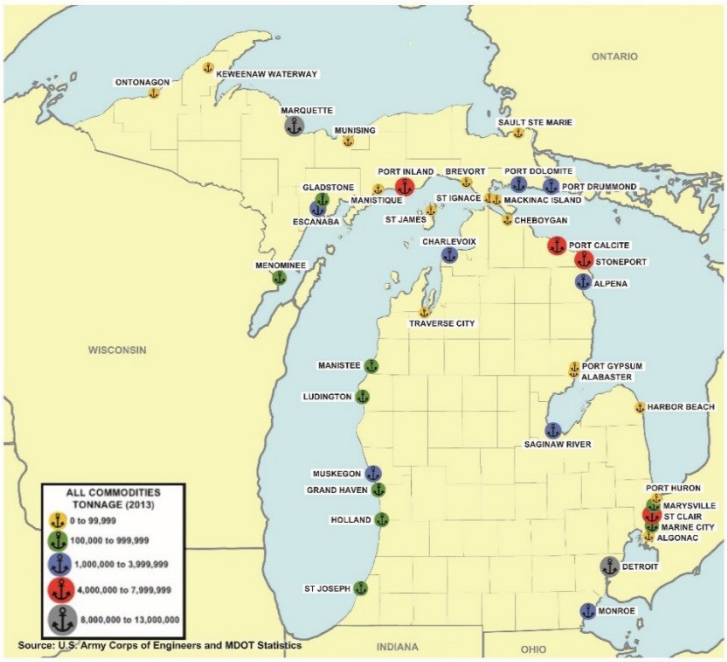
Marine transportation is an essential component of Michigan's freight conveyance system and is critical to regional economies and many coastal communities. The Great Lakes and their navigation channels provide access to ports around the world for Michigan's products. There are approximately 35 active cargo ports that ship or receive a total of 65-75 million tons of cargo annually. Principal commodities include stone, iron ore, coal, cement, petroleum and chemicals. Several additional ports accommodate ferry services or other commercial activities.

The maritime system is a partnership between the public and private sectors. The federal government generally maintains the waterside infrastructure by way of Congressionally-authorized navigation channels, aids-to-navigation, and other services. In recent years, however, the federal government has not provided adequate funding to fully maintain this public infrastructure. The private sector typically provides the marine terminals, docks, cargo vessels, and necessary access channels from the docks to the reach the public channels. It should be noted that the private sector ultimately controls cargo movements and makes modal transportation decisions.

Michigan's 35 active cargo ports annually ship and receive a total of 65-75 million tons of goods and raw materials

There are several ongoing initiatives focused on managing commercial ports. Great Lakes state and provincial leaders have begun a region-wide assessment of maritime infrastructure, long-term funding, and management through their Great Lakes Maritime Initiative.[2] Several regional initiatives, such as the Great Lakes International Trade and Transport Hub (GLITTH), are underway to coordinate and leverage infrastructure assets to increase international trade through Michigan. Additionally, local efforts are underway in Detroit, Monroe, Muskegon and the Saginaw River to upgrade port infrastructure using public and/or private investments.

Vibrant waterfronts can and do include commercial ports and operations such as in Detroit, Sault Ste. Marie, Port Huron and Marquette. Significant opportunities exist to further develop Michigan's ports as multimodal transportation hubs. The integration of local and regional community and economic development plans is necessary for prioritizing and leveraging capital investments. For example, while agriculture is a very important part of Michigan's economy, few of our commercial ports currently ship or receive agricultural products. This potential growth area could significantly benefit both the public and private sectors.



Tonnage for Michigan Commercial Ports and Harbors: Courtesy of the Michigan Freight Plan

Goal: Michigan Communities Use Water as a Strategic Asset for Community and Economic Development.			
Outcome: Economic and Community Development Plans and Efforts Fully Leverage Water Assets to Create Great Places to Live, Work and Play.			
#	**Recommendation**	**Implementation Metric**	**Lead Actor**
1	Emphasize water resources as assets in state, regional and community planning efforts to provide appropriate, sustainable protection and to fully leverage community-based economic opportunities.	Increase number of communities participating in the Redevelopment Ready Communities® program and those who work through the Waterfront Best Practices.	MEDC, MDEQ, MDNR, Regional governments and planning organizations, Local units of government
2	Support an annual mayor's summit focused on creating high-quality communities that leverage strategic water assets.	Increase in property values as a result of increased economic activity and investment on or near water in a community, watershed or region.	Mayors
3	Provide in-depth technical assistance to support communities with developing and implementing community visions and strategies for waterfront redevelopment, access and use.	Increase number of communities participating in the Redevelopment Ready Communities® program and those who work through the Waterfront Best Practices.	Regional and interagency teams, Michigan Municipal League; County and Township Associations; Local economic development organizations, and Regional councils
4	Prioritize investments around strategic economic assets of commercial harbors and long-term, sustainable infrastructure.	By 2020, increase the volume of cargo handled at marine terminals receiving public funding for infrastructure projects.	MDOT, MEDC, MDNR, MDEQ's Office of the Great Lakes, Governor's Office of Public-Private Partnerships, Commercial maritime interests, Industry, Local planning professionals

SUPPORT

water-based recreation

Michigan's four Great Lakes, 11,000 inland lakes, 76,000 miles of rivers and streams and 3,200 miles of freshwater coastline provide abundant water-based recreation opportunities, making Michigan a great place to live and play while supporting a thriving tourism industry. Tourism is one of the largest industries in Michigan, generating $17.7 billion of direct spending, $995 million in state taxes and 200,000 jobs in 2011.[3] Water-based tourism and recreation attracts and retains people who want to live, work and play and is an important part of growing a sustainable water-based economy in Michigan. However, challenges and opportunities exist in sustaining and expanding the state's water-based recreational opportunities.

Maintaining access to water resources while simultaneously preserving their integrity is critical to their long-term sustainability and integral to conserving the quality of life that makes Michigan a great place to live and a premier travel destination.

Goal

Michigan's water resources support quality natural resources, recreation and cultural opportunities

Outcome

Waters of the State are world renowned for recreational pursuits such as hunting, fishing, boating, and swimming

Measures of Success

- Increase in water-based recreation and tourism.
- 90% of the population has convenient access to swimmable and fishable water.

Improve Beach Health

Beach days are among the fondest memories of Michiganders' summer vacations, but pathogens such as E. coli threaten this treasured asset. The Great Lakes and inland public beaches are monitored for pathogens on a voluntary basis by local health departments, supported by MDEQ which awards grants for this purpose. In 2015, 98 beaches reported 212 incidents of E. coli exceeding accepted water quality standards. While the durations were typically short, usually one or two days, any closure impacts recreation and tarnishes the state's image.

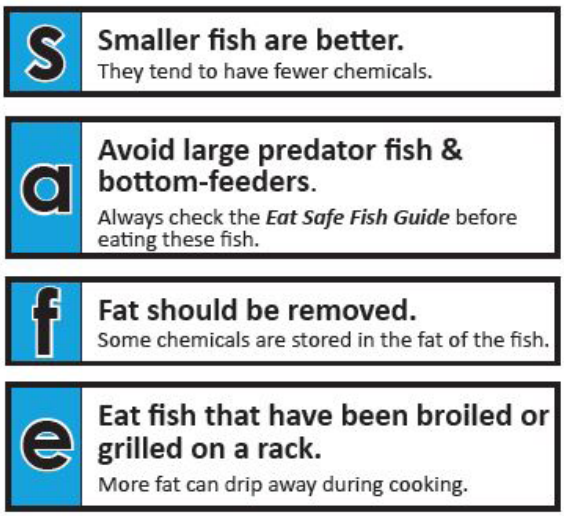
Causes of beach contamination include releases from wastewater treatment plants, sewer overflows, leaking septic systems, runoff from agricultural operations, and excessive wildlife on beaches. These causes are addressed in other sections of the Water Strategy; however, additional real-time beach monitoring data is also needed to provide timely advisories that protect public health.

Address Fish Consumption Guidelines

Michigan continues to need guidelines detailing safe fish consumption amounts due to ongoing and historical deposition of persistent, bio-accumulative toxic (PBTs) pollutants like perfluorooctane sulfonate (PFOS), mercury, PCBs and banned pesticides such as DDT. Addressing sources of ongoing deposition and sites of legacy contamination is critical to restore human use and enjoyment of fishery resources.

In some cases, global sources are contributing to atmospheric deposition of mercury and other PBTs and will require a state, regional and national approach to reduce emissions. Michigan's participation in national and regional efforts to eliminate anthropogenic (human-caused) mercury use and releases from fuels or raw materials, or from uses in products or industrial processes, is critical to having an impact on this global problem. The MDEQ's 2008 Mercury Strategy Report estimated most of the mercury released into the environment is released into the air, with a smaller amount being released directly to water and land. A 2002 inventory estimated about 7,000 pounds of mercury were emitted into the air in Michigan that year. About 37 percent was from coal combustion and about 30 percent was from the use of mercury in manufacturing and industry. This estimate has been used to establish a baseline for measuring progress toward reducing emissions. Between 2002 and 2011, ongoing pollution prevention activities, permitting and regulations resulted in mercury air emission reductions of 1,000 to 2,000 pounds of mercury. Coal-fired power plant retirements and use of additional coal combustion control equipment may eventually reduce mercury emissions in Michigan by 80 to 90 percent.

Although atmospheric deposition of mercury, PCBs and other PBTs contribute contaminants to fish in most Michigan water bodies, the highest concentrations measured are associated with legacy contamination



MDHHS "Eat Safe Fish" guidelines inform communities about best practices regarding fish consumption

sites. For example, the "do not eat" guideline covers all species of fish on the Kalamazoo River between Morrow Dam and Lake Allegan because of past practices at paper mills. In several Areas of Concern (AOC), the fish consumption beneficial use impairment (BUI) designation has been removed due to restoration efforts over the last several decades. Although improved, fish consumption guidelines will continue to be in place for the undetermined future at these sites – even after BUI removal and AOC delisting – due to lingering (although lessened) contamination in the sediment, as well as ongoing air deposition. The GLRI has enabled rapid progress toward restoring human uses of fishery resources, and sustained support for the GLRI is needed to continue progress.

Monitoring of fish for legacy and emerging contaminants is important to protect public health. In 2014, perfluorooctane sulfonate (PFOS), a key ingredient in fire-fighting foam, first appeared in Michigan Department of Health and Human Service's Eat Safe Fish Guide as a chemical of concern for fish consumption for the Au Sable River near the decommissioned Wurtsmith Air Force Base in Oscoda. In 2015, PFOS fish consumption guidelines were also included for the Flint River, Rogue River and St Joseph River. Michigan must continue to prioritize and institutionalize the continued monitoring of legacy and emerging contaminants in order to ensure that Michigan maintains its status within the Great Lakes as a leader in the adoption and implementation of best available science to protect public health.

Ensure Sustainable Recreational Harbors

Michigan has more than 80 recreational harbors that contribute significantly to the quality of life and economic vitality of host communities. In addition, harbors help support Michigan's $4 billion boating industry.[4] Unfortunately, many harbors are in poor or failing condition and limited financial resources hamper sustainability.

The Michigan Department of Natural Resources completed an inventory and condition assessment of recreational harbor infrastructure in 2014. Additional research, planning and prioritization is needed to identify critical sources of sediment that diminish the value of the harbor and increase maintenance costs, prioritize long-term capital investment needs, and create strategies to market harbors.

Too often, communities have not realized the full economic and social value of their harbors; they are rarely integrated into community and economic development plans

A multi-agency and university partnership is also conducting assessments to evaluate the complexity of the issues facing harbors while developing community guidance to ensure sustainability. Too often, communities have not realized the full economic and social value of their harbors; they are rarely integrated into community and economic development plans. This integration is necessary for prioritizing and leveraging capital investments. Variable lake levels, infrastructure condition and depreciation, access, boating trends and future use of the harbor all need to be considered to ensure harbor and marina sustainability.

Increase Access to Lakes, Rivers and the Great Lakes

Since water plays such a pivotal role in many Michiganders' lives, access has always been a priority. In 1939, the Legislature first earmarked funds to purchase water frontage to improve access for fishing and boating. Since then, more than 1,200 public launching sites have been developed for boaters. The Natural Resource Trust Fund remains an important part of providing recreational opportunities, including access to Michigan's waters, but with more than 11,000 lakes and thousands of miles of rivers, streams and Great Lakes coastline, significant gaps in access remain. The 2013 Michigan Department of Natural Resources Managed Public Lands Strategy and the Great Lakes Water Trail Plan both recognized this need. When addressing access gaps, protection of ecologically sensitive areas needs to remain foremost, and increasing access for people of all abilities to experience and enjoy Michigan's water resources should be a priority.

Designate Water Trails

Michigan has endless opportunities for establishing a spectacular water trail system. Much of the framework for such a system already exists, and some water trails have recently been developed on several rivers using existing access sites, harbors of refuge and waterside campsites. Statewide criteria for designating a trail is needed, including level of difficulty, distance between access sites, and trail amenities such as nearby campgrounds, restaurants and restrooms. Ensuring these areas are accessible by transit and non-motorized systems is important to creating a statewide water trails system.

Goal: Michigan's Water Resources Support Quality Natural Resources, Recreation, and Cultural Opportunities.			
Outcome: Waters of the State are World Renowned for Recreational Pursuits such as Hunting, Fishing, Boating, and Swimming.			
#	**Recommendation**	**Implementation Metric**	**Lead Actor**
1	Expand the use of real-time monitoring and source tracking techniques at high risk beaches by local health departments, counties, communities and universities, and address sources of beach contamination.	By 2020, all of Michigan's water meets total and partial body contact designated uses with no closures or advisories. Real-time monitoring is in place at all high-risk beaches.	MDEQ, Local health departments, Local units of government, Universities
2	Continue national, regional and state coordination of mercury reduction activities including implementation of the Great Lakes Mercury in Products Phase-Down Strategy, the Great Lakes Emissions Reduction Strategy and MDEQ's mercury regulations and pollution prevention activities.	Reduce the mercury levels in edible portions of fish from the Great Lakes, inland lakes and streams to below 0.35 parts per million by 2020.	MDEQ, MDHHS
3	Prioritize and institutionalize the continued monitoring of fish for legacy and emerging contaminants to protect public health.	By 2018, fund and continue to support monitoring of fish for legacy and emerging contaminants.	MDEQ, MDHHS, MDNR, Legislature
4	Prioritize infrastructure needs for repair and upgrade of public recreational harbors and their landside access. Support investments in communities involved in long-term harbor sustainability planning and implementation that integrate community, economic development and watershed and resiliency planning.	By 2017, develop a prioritized list of infrastructure needs. By 2020, increase the number of communities that integrate harbors as a strategic asset in community, economic development, watershed and resiliency planning over a baseline established in 2016.	MDNR, Waterways Commission, MDEQ, MDOT, ACOE, MEDC
5	Establish a harbor town program and improve marketing of harbors. The program should work with MDEQ to address sources of upstream sediment, sediment reduction and relocation strategies.	By 2017, establish a Harbor Town program. Work with stakeholders to address sources of upstream sediment, sediment reduction and relocation strategies.	MDNR, MDEQ Local units of government
6	Work with local partners to provide public access every five miles on the Great Lakes, on all priority lakes over 100 acres in size and on every five miles of navigable water, as environmentally appropriate.	Establish public access every five miles on the Great Lakes and on all priority inland lakes larger than 100 acres.	MDNR, Local units of government, Lake Associations, NGOs
7	Work with stakeholders to develop and implement a designated water trail system for inland waterways and along the coast and market water-based recreational opportunities.	By 2020, a designated water trail system has been established by the MDNR.	MDNR, Local units of governments, NGOs

PROMOTE
water-based economies

Michigan's water and Great Lakes, in general, have played a defining role in the state's economy starting with fur trading and continuing across time through the lumber boom, agriculture, manufacturing and more recently with tourism. Michigan should build off these past experiences by highlighting and marketing its strategic advantages as the Great Lakes state, growing leadership and harnessing talent in research and development, accelerating innovation in water technology and optimizing water efficiency. This could represent a whole new chapter of the state's long-standing water-centric economic history. However, rather than degrading our water in exchange for economic growth as we have in the past, we can create pioneering solutions for growing water-based economies that improve community stewardship and sense of place simultaneous with economy growth.

Michigan and other places across the globe face severe and complex challenges in water quality and quantity. The state is well-positioned through its research, talent, innovation, industrial design, capital, fabrication and deep manufacturing expertise to be a powerhouse for solving these challenges and growing its economic opportunities around water and to do so in a manner that ensures sustainable use and stewardship of the resource. Opportunities for collaboration abound among industry, governments, economic developers and academia (in Michigan and the region's neighboring states and Canada) to direct water research and support new technologies and innovation.

Market Michigan's Strategic Advantages

Currently, Michigan hosts about 350 companies that provide technology, goods and services related to the supply, treatment, distribution, storage, transport, recycling, rehabilitation and conservation of water. As a 2014 University Research Corridor analysis highlighted, more than one out of five jobs in the state are strongly linked to water, a number that does not include outdoor recreation and tourism.[5]

The understanding of the importance of water as central to public health, healthy ecological systems, people and economies is growing. Electric utilities, mining, steel manufacturing and the food and agricultural sector face increasingly higher costs as a result of water scarcity across the nation. Water-intensive companies in water-stressed areas are at the highest risk of experiencing production disruptions, stranded assets, increased capital costs and community conflicts over shared resources.

Goal

Michigan has a strategic focus on water technology and innovation to grow sustainable water-based economies

Outcome

Policy, innovative practices and technologies are developed and adopted to grow sustainable water-based economies

Measures of Success

- Michigan is recognized as a place to invest and locate a business due to its support of sustainable water technologies, water conservation, and high quality of life.
- Increase in percentage of economic output per gallon of water utilized.
- Increase in water sector employment and earnings at the statewide and county level.

Water is a key factor in the economic health of many corporations and therefore a significant and knowable element in overall corporate stock price and volatility. In a 2015 survey, the World Economic Forum ranked water crises first as a critical risk to the global economy.[6] According to a Pacific Vox survey of 50 Fortune 500 companies from a broad cross-section of industries nationwide, concern about water scarcity has grown dramatically during the past five years. By 2018, 86 percent of the companies expect to consider water availability in their site selection, up from 37 percent in 2008.[7]

Water is now seen as an increasing factor in the investment decisions affecting the deployment of trillions of dollars of capital. Researchers, financial managers, investors and corporations are beginning to fully understand how water contributes to or mitigates risks throughout the business cycle. Risks are not just within how a company operates but also in how suppliers and business partners manage that risk as well throughout the supply chain. A key challenge that investors face is how to quantify and value financial risks from regulatory, physical and reputational impacts from water. The University of Michigan is conducting innovative research about water risk and corporate behavior, but further research is needed about the value the state's water resources can add to managing water-related risk, stock price volatility and overall financial performance.

Optimize Efficient Use of Water in Business, Utilities and Municipalities

If Michigan's abundant clean water supply is efficiently managed, the state's economic capacity can grow while ensuring water stewardship. In a state with generally abundant water resources, it is difficult to appreciate that water is not disposable and that every drop is valuable. However, there are some areas of the state experiencing localized water scarcity due to increasing demands from groundwater withdrawals. An appreciation for efficient use of water needs to spread across the state to ensure the sustainability of this precious resource. All Michiganders have an obligation to be good and thoughtful stewards of this global treasure by using water more thoughtfully and efficiently.

Under the Great Lakes Compact Agreement, each state is required to establish water conservation measures for each water use sector; however, limited data is available on current water use for each sector beyond gross numbers and anecdotal information. Without goals or objectives, we cannot evaluate progress in reducing water use impacts and determine if improvements are needed.

Michigan's residential, industrial, and commercial sectors are all showing increases in water conservation.

In 2012, the State formed the Water Use Advisory Council and tasked it with providing insight and advice to the State on Michigan's Water Use Program which includes the Great Lakes Compact, water withdrawal and water use conflict. One specific charge to the Water Use Advisory Council was to provide advice on water conservation and efficiency goals, objectives and voluntary measures. Recommendations from this Council were issued in December of 2014 and initially were not part of the draft language in the Water Strategy.[8]

A host of the recommendations in the report related to water conservation – twenty three in all - have now been incorporated into the implementation plan for the Water Strategy. Two recommendations from that report in particular bear repeating here.

> **1.** "Michigan should improve its water use-related data management program. This includes improving the quality of current water use reporting, the capacity to track water usage, the result of conservation measures, and the development of water demand analysis for individual water use sectors. In particular, each water use sector should design the appropriate data sets in order to track water use, progress on water efficiency and conservation, and develop demand analysis.
>
> Development of these data sets must balance the need to be generally applicable to a sector or sub-sector and the ability to be tracked over time with the complexities of the circumstances faced by each particular user. The state-specific outcomes described in Recommendation WC 5.1 can inform the development of these data sets. Ideally, these data sets could be recommended for Great Lakes Basin-wide use."
>
> **2.** "The MDEQ should incentivize water conservation and efficiency in the public sector by rewarding the implementation of water conservation and efficiency measures when applying for State funding for water infrastructure projects. This could be accomplished by providing significant points to project plans from water systems that already have a water conservation and efficiency plan, thereby increasing the likelihood that the project will be funded."

Progress toward increasing water conservation in Michigan is underway. Residential, industrial, and commercial sectors are all showing increases in conservation, as is agriculture. While agricultural use of water, and in particular agricultural use of groundwater is increasing, the efficient use of that water for irrigation purposes is also increasing through the deployment of technology and information systems. Businesses are focusing efforts around

water sustainability to improve their bottom line and to further comply with environmental standards. Others are recognizing the importance of water globally and are beginning to work more holistically outside corporate walls. For example, major Michigan corporations like Ford Motor Company, Consumers Energy, General Mills, Whirlpool, Amway and Dow, among others, are all heavily engaged in water management as part of their corporate sustainability and operational programs. Many of these companies have set aggressive water efficiency targets. For instance, Consumers Energy has set a water reduction target of 20 percent between 2012 and 2020. Ford Motor Company set a goal of reducing its water footprint by cutting the amount of water used per vehicle by 30 percent globally between 2009 and 2015.

The Great Lakes and St. Lawrence Cities Initiative (GLSLCI) also urged cities to participate in the GLSLCI Water Conservation Framework to help meet its commitment of reducing water use within city limits by 15 percent in total water usage by 2015 using 2009 water consumption levels as a baseline.

Conservation makes not just social sense, but business sense. Water is heavy, requiring a significant amount of energy to move through the system. Measureable water loss can be attributed to leaking and poorly maintained municipal infrastructure. In addition, cleaning and purifying water for drinking water, manufacturing and discharge is very costly. Nationally, between 4 and 13 percent of all energy is used to pump and treat water for waste management or for industrial and commercial processes.

For businesses and industries that require water use as a core part of their operations, energy (and cost) savings can happen in two ways: increasing the efficiency of pumping and treating water, or by reducing the total use of water per capita, per industrial or municipal process. Capital asset management planning and infrastructure upgrades should reflect these goals.

Wastewater reuse through energy generation also provides economic opportunities. Innovative solutions to wastewater management can minimize water and energy footprints. Firms like Moore and Bruggink have reengineered Greenville's wastewater treatment facility to produce its own energy, reducing costs and energy consumption by more than 30 percent.[9]

In addition to using less water through efficiency measures, water reuse should be explored in situations where potable water quality is not required and risk for cross-contamination is low. This must be done with critical attention to public health and infrastructure. Michigan should develop standards, protocols and strategies to protect public health and preserve surface water and groundwater resources while facilitating rain and grey water reuse in appropriate situations.

Optimize Water Sustainability Practices for Agriculture

Agriculture is another example of a major water user in Michigan that has made significant advancements to improve efficiency. Water, energy and food are inextricably linked. Growing populations, improving technologies, high crop prices and specialty crops like seed corn have led to expansion of irrigation and agriculture production into regions of the state where it was once unfeasible. Biotechnology advances, especially shorter-season crop varieties, and climatological and meteorological changes with accompanying longer growing seasons make farming in the northern part of the state a more viable opportunity.

As agriculture continues to grow in Michigan, there will be more pressure on aquifers and greater potential for use conflicts. More intensive use of land will require greater management of water. While total agricultural water use is increasing, the efficiency of the transformation of water into crops is also increasing. There are opportunities for agriculture to use more sophisticated irrigation delivery and water management systems to minimize overall water use per unit output. Continued efforts to increase efficiency can reduce conflicts in localized areas that have water shortages, reduce related energy costs, and reduce water use impacts. There are many synergies and trade-offs between water and energy use and food production. The goal is not necessarily to reduce water use, but to reduce the impacts of agricultural water use on ecological systems and to use it more judiciously.

Aquaculture is another area that could thrive based on Michigan's plentiful water supply and high water quality. In a world demanding ever-increasing amounts of high-quality fish and protein, growing the state's aquaculture industry will require significant innovation in water technology to ensure sustainability and protection of water quality and the health of current fisheries. In particular, industry and the state should continue to support closed loop or recirculating

systems. Working together to create models and incentives for lowering energy costs of production, improving water filtration and strengthening supply chains for commercial aquaculture systems will enable the industry to grow substantially in an ecologically responsible fashion.

Efficient use of water also affects the processing and manufacturing supply chain. Companies like Kellogg, MillerCoors and General Mills are focusing efforts around water sustainability by working with the agricultural community to implement best practices such as efficient delivery of water to crops, efficient use of water, and impact accountability. In areas with water scarcity issues like Texas, Colorado and other western states, technological advancements are reducing pressure on aquifers with inadequate recharge. Establishing targets for water efficiency in areas with localized water stress may reduce the potential for conflict.

Another recommendation from the Water Use Advisory Council's report is pertinent to the agriculture sector. "Based on the water use trends, more focus needs to be placed on conservation and efficiency in the Irrigation Sector. MDARD has developed comprehensive guidance in the form of Generally Accepted Agricultural and Management Practices (GAAMPs), which includes guidance in preparing a water conservation and efficiency plan. MDARD and Michigan State University (MSU) Cooperative Extension should continue to provide and expand training and outreach to the Irrigation Sector to increase the use of these GAAMPs."

Accelerate Innovation and Technologies to Solve Water Challenges

Michigan has opportunities to advance the technology, science, research and education required to improve water management. These water technologies can be an economic driver for the state. To capture its share of the global water technology sector predicted to reach $1 trillion annually by 2020, Michigan must nurture an environment that fosters water entrepreneurs, supports a high-performing water technology sector, and leverages the state's innovation, research, development and extensive manufacturing capabilities.

Michigan faces a number of complex challenges regarding water quality and quantity but the state also has a history of developing innovative water technologies to help meet those challenges while exporting those technologies to global markets.

Different water sectors – municipal, agriculture, manufacturing and industry – all have specific needs requiring technological solutions such as maximizing water efficiency, minimizing water loss, meeting more rigorous discharge standards, and dealing with new forms of contamination from emerging chemicals and pharmaceutical products. A recent report on Michigan's Blue Economy by the Michigan Economic Center and Grand Valley State University Annis Water Resources Institute highlights examples of successful efforts to develop and deploy cutting-edge water technologies to address some of these needs and challenges.[10]

Michigan has the ideas and research; academia, businesses, and end users need to align goals and desired outcomes for technologies to actually reach the market. In addition, Michigan community colleges provide a mechanism for needed job training to expand water-related industry sectors. Focusing on innovation in water technologies does not represent a philosophical change to the state's approach to economic development but rather recognizes the importance of aligning interests, making clear statements about priorities, and connecting the pieces together to drive entrepreneurial innovation. By building robust public-private partnerships, Michigan can link innovation, research and development, capital investment, entrepreneurialism, and end users to achieve desired environmental, economic and social outcomes. When an accelerator of public and private funding is combined, ideas can move more quickly from design to deployment and markets.

Goal: Michigan has a Strategic Focus on Water Technology and Innovation to Grow Sustainable Water-Based Economies.			
Outcome: Policy, Innovative Practices, and Technologies are Developed and Adopted to Grow Sustainable Water-Based Economies.			
#	**Recommendation**	**Implementation Metric**	**Lead Actor**
1	Highlight the State's competitive advantage as a highly attractive place for business creation and investment because of our abundant natural water assets, water research capabilities, highly skilled talent, economic development expertise, manufacturing expertise and powerful tourism and business-marketing brand.	Increase the number of water-dependent companies and investments including water dependent tourism companies locating in Michigan. Specifically track aquaculture flow through and recirculating technology and related opportunities.	MEDC, MDNR, MDARD, Academia
2	Conduct a comprehensive review of all state and local laws, regulations and rules which impact water to remove barriers, inconsistencies, overlaps and reduce regulatory process to improve and facilitate investment in sustainable water-based economies in Michigan.	By 2017, complete a comprehensive review of all state and local laws, regulations and rules which impact water to identify barriers, inconsistencies, overlaps and reduce regulatory process to improve and facilitate investment in sustainable water-based economies in Michigan.	LARA, MDEQ, MDARD, DNR, MEDC
3	Establish voluntary water efficiency targets for all major water sectors to reduce water use impacts and costs.	By 2020, develop a baseline for water usage, data collection and definitions to inform development of water conservation goals and objectives. Collect data for two years. Increase by 20% the number of businesses, industries, and municipalities with water efficiency within their water management plans.	MDEQ, MDARD
4	Promote innovative technologies that reduce cost and water loss or convert waste products to usable materials.	By 2020, increase the number of new, innovative and cost-effective technologies, pilot projects, and startups that are commercialized, come to market and result in connections with end users to reduce costs and water consumption, or convert waste products to usable materials and produce energy over a baseline established in 2016.	MDEQ, MDARD, MEDC
5	Develop a water conservation and reuse strategy for the State, local governments and public and private facilities that incorporates the use of green infrastructure, grey water systems and energy production that includes recognition programs.	By 2018, develop a water conservation and reuse strategy that identifies major sectors by water use and their locations.	MDEQ, MDARD, MDOT, NGOs

6	Fund a pilot project, through a competitive bid process, for the initiation and evaluation of a new model for wastewater management. This pilot program will assess the opportunities and barriers to creating a "Water Resources Utility of the Future," focused on: • Reclaiming and reusing water • Extracting and finding commercial uses for nutrients and other constituents • Capturing waste heat and latent energy in biosolids and liquid streams • Generating renewable energy using its land and other assets • Using green infrastructure to manage storm water and improve urban quality of life	By 2017, pilot project is funded.	Legislature
7	Define measures of agriculture water conservation and establish voluntary targets for utilizing best management practices (BMPs) that reflect conformance with the Irrigation Water Use Generally Accepted Agricultural and Management Practices in areas of existing or potential water stress.	By 2017, using information collected in the water use reporting tool, develop a baseline for the number of farms with irrigation systems utilizing best management practices (BMPs). Increase the number of producers located in water stressed regions that are utilizing BMPs and are considered in conformance with the Irrigation Water Use Generally Accepted Agricultural and Management Practices by 2020.	MDARD, Universities, Water use sectors
8	Enhance voluntary water conservation measures through technology and outreach for agriculture to optimize water use while reducing impacts and costs.	By 2017, develop a baseline for water usage, data collection and definitions to inform development of water optimization goals and objectives. Increase the number of agricultural sectors that have water efficiency plans and water optimization targets by 2020.	MDARD
9	Create a strategic focus on water innovation to attract and accelerate new technologies to market through a business-led council comprised of private investors, entrepreneurs, corporations, public agencies and universities, and nongovernmental organizations to better manage water challenges in Michigan and worldwide.	By 2020, increase the number of new, innovative and cost effective technologies, pilot projects, and startups that are commercialized, come to market and result in connections with end users to solve water problems over a baseline established in 2016.	MDEQ, MEDC, MDNR, MDARD
10	Create strategic focus through the State's existing public and private research and development assets, the Universities' Water Centers and Institutions, and community colleges on education, innovation, talent development and research focused especially on critical water challenges.	By 2017, conduct an assessment of Water Centers and research institutions' current focus on water challenges and water related research areas. Convene leadership from these public and private institutions to develop a set of shared strategic goals to address critical water challenges.	MDEQ, MDNR, MDARD, Water centers, Universities, Community colleges

Part III

Ensure Clean and Safe Water

Invest in Water Infrastructure

ENSURE

clean and safe water

Clean, safe water is fundamental for human life and for functioning and sustainable aquatic systems. It is equally fundamental to Michigan's economy and to ensuring high-quality places to live, work and play.

Michigan faces complex challenges in addressing water resource issues because of a wide range of historic and ongoing activities such as deposition of mercury, legacy pollutants (i.e. polychlorinated biphenyls (PCBs)), chemical contamination, nonpoint sources of excessive sediment and nutrients (i.e. phosphorous), harmful algal growth, changing climate, urban and rural runoff, hydrologic impairment of rivers and streams, contaminated sediment, and invasive species. All of these things continue to stress drinking water supplies, groundwater resources, aquatic systems, water-based recreation and local economies.

During the past 100 years, water resource concerns have shifted largely from regulating activities such as effluent pollution and dredge and fill operations, to focus on water resource challenges caused by multiple stressors that require both traditional and new regulatory approaches, and innovative and incentive based solutions. Protecting and restoring water quality is critical to ensure ecosystem function while supporting current and future human uses of Michigan's surface and groundwater resources. More recently, water resource concerns have been focused on providing access to safe potable water not just from the source, which may be surface or groundwater, but once it is treated and delivered through infrastructure. Ensuring public water supplies are safe is not just about source water protection and water testing at the water treatment plant; it is also about ensuring that once it's treated it is reliably delivered to customers to use with confidence for drinking and sanitation.

Government has a responsibility and a duty to protect public trust resources, ensure public health and safety and provide standards for safe treatment and delivery of water for drinking and sanitation. Protection of public health requires government to ensure safe and effective delivery of water through its infrastructure. Moreover, in cases where it fails to meet these standards, government at all levels must have policies and procedures in place that ensure intergovernmental and interagency communication and public engagement. It must also implement comprehensive action plans to swiftly address any sources of contamination. In addition, citizens also have a responsibility to be good stewards of our water resources and play a role that protects the quality and safety of their drinking water.

Goal

Michigan's water resources are clean and safe

Outcome

Surface and groundwater are managed to support sustainable human uses and ecological function

Measures of Success

- 100 percent of the population has safe drinking water with no reported violations of health-based standards.
- No drinking water advisories, beach closures or aquatic life impairments due to harmful algal blooms.
- No designated use impairments due to failing on-site wastewater systems.
- No new designated use impairments due to existing or emerging pollutants of concern.

Protect Drinking Water Supplies

Ensuring adequate and safe drinking water for all of Michigan's nearly 10 million residents as well as visitors is essential to protecting public health. Michigan has more than 1,350 community water systems serving approximately 7.4 million residents. The remaining 2.5 million residents rely upon very small privately owned public water supply wells or a private, individual home well, neither of which have continued monitoring or oversight.

Additionally, Michigan also has more than 9,000 noncommunity public water systems that meet the definition of a public water system because they provide drinking water to 25 or more employees and visitors (not residences) on a daily basis, such as a school, restaurant or campground that use a well.

While protection of all water resources in the state is essential, protection of those waters identified as contributing to drinking water sources should be of the

highest priority. Michigan has an estimated 2 million improperly abandoned water wells that pose a risk to Michigan's water resources. These abandoned wells can act as a direct conduit between the surface and underlying aquifers as well as between aquifers. These conduits can result in surface contaminants flowing into private or public drinking water supplies.

The lack of statewide regulations or controls on the installation of closed-loop geothermal borings poses additional risks. Improperly located or constructed closed-loop geothermal borings have the same potential to harm aquifers as improperly abandoned water wells. Many vertical geothermal borings are installed at the same depths as drinking water wells, but have no regulatory oversight to ensure installation does not create a direct conduit for contaminants to reach the aquifer.

5.4 million Michigan residents rely on surface water sources for drinking and sanitation

In many areas of the state, nitrate contamination is a concern. In Michigan, the U.S. Geological Survey regards nitrate-N levels of more than 2 milligrams/liter in water as a sign that human-related nitrate sources have adversely affected the water. In rural areas, elevated levels of nitrate can be associated with animal manure and agricultural fertilizers unless they are properly managed. Septic systems can also serve as a source of nitrate contamination, though that risk is minor if the systems are designed and maintained for nitrogen removal and water wells are properly sited, constructed and maintained.

Additionally, businesses and industries generate wastes that can threaten groundwater quality if not handled properly. Groundwater contamination resulting from improper waste disposal and chemical handling threatens public health and the environment, resulting in significant cleanup costs to taxpayers and businesses. In addition, when contamination of public water supplies occurs it can result in high costs to public water suppliers and taxpayers to provide alternative water or replace contaminated drinking water supplies. Most of the costs for providing alternative water or the replacement of contaminated drinking water supplies has been covered by the use of voter approved bond funds (1988 Environmental Protection Bond and 1998 Clean Michigan Bond). Bond funds have paid for alternate water and the replacement of contaminated drinking water at 10,000 sites in Michigan. At this time, all of the 1988 bond funds have been committed and all but 14.9 million dollars of the 1998 bond funds have been committed to date. The MDEQ has requested the appropriation of the remaining funds from the legislature for fiscal year 2017. The state's ability to provide safe alternative drinking water supplies will cease unless new funding is secured.

Michigan needs to maintain and expand public water supply source water assessment program efforts. The MDEQ is responsible for designating source water protection areas, inventory of contaminants within, assessing source water susceptibility to contamination, and informing the public of the results. Source water protection areas for groundwater systems are defined as an area which represents the surface and subsurface area surrounding a water well or well field, which supplies a public water supply, and through which contaminants are reasonably likely to move toward and reach the water well or well field within a 10-year time of travel. Source water protection areas for groundwater systems can be an area which has been approved by the MDEQ in accordance with the state of Michigan Source Water Protection Program or a provisional delineation through the use of the Michigan Groundwater Management Tool. Source water assessments are based on the actual protection area, rather than isolation distances, and are being updated as conditions change or new sources are approved.

Source water protection areas for surface water supplies are defined through the Assessment Protocol for Great Lakes Sources (August 2000).[1] This protocol identifies critical assessment zones around each intake and where these zones intersect land defines the source water protection area for Great Lakes intakes. Source water protection areas for inland surface water intakes are defined as the watershed upstream from the intake. Source water assessments determine the susceptibility of

drinking water sources and provide prioritization to where source water protection efforts are needed. Surface water assessments were completed in 2000-2004 and provided a susceptibility determination for each intake. Assessments may also provide information as to where additional monitoring may be required.

The Source Water Protection Program was developed as a requirement of the 1986 amendments of the Federal Safe Drinking Water Act with the purpose to protect public water supply systems from potential contaminants to groundwater and surface water sources. This is a voluntary program, including financial incentives, and is implemented through a cooperative state and local effort. The MDEQ Source Water Protection Program works with other local, state and federal agency programs to enhance drinking water protection in addition to helping communities develop and implement protection program plans.

Although implementation of a Source Water Protection Program is voluntary, Public Water Supply Systems who choose to participate must develop a local Source Water Protection Program consistent with the guidelines established by the MDEQ. These efforts are best accomplished through collaboration with other state and federal water and environmental resource programs to best integrate drinking water protection in other program activities.

For public water supply systems relying upon groundwater sources, one of the biggest hurdles to implementing a Source Water Protection Program has historically been the inability to effectively evaluate the vulnerability of these groundwater sources relative to potential sources of contamination. A means of assessing groundwater flow regimes and identifying the source water protection area for public water supply systems throughout the state has been developed and enhances the integration of drinking water protection into other MDEQ programs. Other regulatory programs may access Source Water Protection Areas, thereby allowing these programs to provide a greater level of protection to areas that are contributing to public drinking water supplies.

With 5.4 million residents relying upon surface water sources, these communities may also develop Surface Water Intake Protection Plans for their drinking water sources. Guidelines have been developed for Surface Water Intake Protection Programs and communities are encouraged to proceed with delineating areas contributing to their source water and identifying potential sources of contamination. Because the contributing area for a surface water source may encompass entire watersheds, this task is daunting but no less significant given the potential impacts of not protecting these areas.

No matter the source of drinking water, surface water or groundwater, continued diligence is needed for protection of the source and monitoring of the quality. Drinking water standards need to be reviewed and updated to provide for the best public health protection, or standards need to be created for newly emerging contaminants. Michigan's residents also play a role in the safety of their drinking water. Private well owners should routinely sample for bacteria and contaminants of local concern. Everyone should dispose of household chemicals in a responsible manner. All resident should take precautions, like cleaning faucet aerators, to reduce their exposure to lead in drinking water from plumbing, lead solder and older fixtures. Michigan has varied water chemistry and infrastructure throughout the state. At risk populations should always consult with health care providers regarding the use of a water filter or bottled water to further reduce exposure to lead, arsenic and other contaminants.

Properly Maintain On-Site Wastewater Systems

Michigan has about 1.3 million on-site wastewater systems (septic systems) that serve as permanent wastewater infrastructure for more than 30 percent of homes and businesses. At least 30,000 of these are commercial and community subsurface disposal systems treating sanitary wastewater with flows up to 10,000 gallons per day. Since more than half of new single family homes are built with on-site wastewater systems, this reliance will continue to expand. However, no central system exists that tracks these on-site systems' precise locations, conditions or risks to sources of water. Adequately managed on-site wastewater treatment systems are a cost-effective and long-term option for meeting public health and water quality goals, but the key to their use is in proper siting, adequate management and maintenance.

Only 13 percent of Michigan counties conduct inspections of on-site wastewater systems

Currently, local health departments in only 11 Michigan counties conduct inspections of on-site wastewater systems at the time of real estate transactions. These counties report that the number of systems in some manner of failure or improper operations averages about 10 percent but ranges as high as 23 percent. Assuming an average failure rate of 10 percent across the state, at least 130,000 systems discharging a total of 31 million gallons per day could be experiencing operational problems and adversely affecting local waterways and groundwater. Since local health departments issue only about 5,000 replacement permits annually for existing systems that have failed, there are likely a significant number of unidentified, failing systems statewide.

Michigan is the only state without a specific law related to individual or small-quantity on-site wastewater treatment systems. The systems are regulated to some degree, but the regulatory focus is largely on siting and construction of new systems and not on maintenance, system performance or condition. A combination of local codes and state criteria have contributed to a non-uniform patchwork of regulatory control over conventional septic tank and drain field siting, design and construction. A 2004 MDEQ stakeholder process concluded that the State should develop science-based standards for site suitability, design, operation and maintenance, as well as requirements for oversight and inspection for all systems after construction. In addition, homeowner education about proper on-site system maintenance is needed and a state-facilitated loan mechanism to financially assist homeowners with on-site replacement should be explored. To date, this work has not been completed, and the Legislature has not passed such a statute.

Clean Up Legacy Contamination

Michigan's historic industrial and commercial activities left many areas of legacy contamination. Some of the worst contamination problems in Michigan's waters still exist at superfund sites and in Areas of Concern (AOCs). In addition, the state suffers from more than 7,500 leaking underground storage tank sites and more than 9,700 other sites of environmental contamination. Common sources of contaminants include hazardous substance releases, petroleum products, contaminated sediments, atmospheric deposition, industrial discharges, sewage treatment plant discharges, combined sewer overflows, nonpoint source pollution and runoff from industrial sites. These sources of contamination threaten aquatic life, public health,

create an economic drag on communities and prevent opportunities for use and enjoyment of Michigan's water.

Twelve of Michigan's original 14 AOCs remain on the list of formally designated areas of legacy contamination under the Great Lakes Water Quality Agreement. Today, 41 of the sites' 111 beneficial uses (referring to indicators including benthic life, safe beach use, and wildlife habitat and population health, among others) have been restored, with several more in the process of being formally assessed. Michigan recently celebrated the successful delisting of Deer Lake in Marquette County and White Lake in Muskegon County; all of their beneficial uses have been restored.

Public funds play a vital role in addressing contaminated sites where no responsible party exists or has the ability to fund cleanup activities. These funds are used to investigate the extent of contamination, evaluate and abate the risks associated with the hazardous substances, including providing alternative water supplies and perform cleanup activities to protect the public and environment. They are also used to leverage private resources, stretching their impact. Funding programs like the GLRI (which must be funded annually and therefore is not a certainty), Great Lakes Legacy Act Program, Clean Michigan Initiative Bond, Brownfield redevelopment programs, and Refined Petroleum Fund which helps pay for Leaking Underground Storage Tank cleanups contribute to Michigan's transformation. Their dollars turn blighted, unusable, contaminated properties into opportunities for investment and revitalization in communities.

However, except for the GLRI, these funding sources are now nearly depleted. Continued advocacy for these important federal and state funding programs is needed to continue this transformational work. Critical cleanup efforts are still needed in Michigan to address other areas with significant contamination, including several areas within the Detroit River, the lower reach of the Rouge River, the Pine River in St. Louis and PCBs in the River Raisin, the Kalamazoo River, the Ten Mile Drain on Lake St. Clair and in Torch Lake in Houghton County. While several of the locations mentioned above are currently undergoing corrective action, work at many locations on the Detroit River and the lower section of the Rouge River is just beginning. Michigan cannot afford to give up the progress that it has made to this point, and there is more work to be done.

Prevent Spills and Their Impact on the Environment

Water resource quality is impacted by the release of oils, chemicals, salts and polluting materials from human activities associated with, among other things, industrial sites and the extraction of minerals. A majority of these releases can be prevented through regulatory programs, but releases may still occur unexpectedly. Appropriate actions to prevent, control, mitigate and remediate these releases are critical to avoid and minimize harm to Michigan's surface and groundwater.

For example, in 2015 the Michigan Pipeline Taskforce undertook an effort to assess major pipelines transporting liquid petroleum products around the state. The Taskforce identified and recommended actions within state government to protect the public health, safety and welfare of Michigan citizens and the environment. Some of these recommended actions included coordinated mapping of existing pipelines among state agencies; ensuring that state agencies collaborate on emergency planning and spill response; evaluating whether to establish a Hazardous Liquids Pipeline Safety Program in Michigan and creating a permanent advisory board on pipeline issues. On September 3, 2015 (amended April 19, 2016), Governor Snyder issued an Executive Order[2] creating the Michigan Pipeline Safety Advisory Board.

In addition, the Taskforce evaluated potential actions to address concerns surrounding the Straits of Mackinac pipelines. The recommendations included requiring an independent risk analysis, adequate financial assurances and an independent analysis of alternatives to the existing pipelines. The State anticipates that both the analysis and the reports will be finalized in 2017.

The Lake Huron to Lake Erie corridor which supplies 40 percent of Michigan's residents with drinking water also requires greater stewardship. This international corridor is both a major shipping route and heavy manufacturing area on both sides of the border and has experienced industrial chemical spills and nutrient loadings from combined sewer and sanitary sewer overflows due to severe storm events. Progress has been made to address Combined Sewer Overflows (CSOs) and Sanitary Sewer Overflows (SSOs) through infrastructure improvements; however, more work is needed. The MDEQ is collaborating with Water Treatment Plant operators, SEMCOG, universities, and others on better options to prevent, monitor and respond to spills to protect our drinking water supplies. A model governance structure which includes both Canadian and private sector industry partners is in the planning stages.

Preventing spills is critical. Coordinated emergency planning and spill response, monitoring and sustainable funding is vital to water resources protection. Michigan will continue to pursue preventative measures to protect its surface and groundwater and ensure recommendations from the Michigan Petroleum Pipeline Task Force are fully implemented.

Prevent Environmental Impacts from Emerging Contaminants

New and emerging pollutants like those found in fire retardants and firefighting foams, rocket fuel, and industrial wastes; existing and new pharmaceuticals; chlorides; plastic microbeads; microplastic fibers and pesticides and their metabolites are all now detected in the environment. The risk to humans, wildlife and the environment from any one of these, let alone the combination of them, is not well understood.

The federal government recently mandated the phasing out of environmentally destructive plastic microbeads from personal care products

Michigan uses surface water monitoring programs to identify and assess emerging pollutants as well as commonly used chemicals such as chlorides in road de-icers to ensure that water quality and beneficial uses are not being impacted. The State also relies on EPA's drinking water standard setting process, which includes periodic monitoring for new contaminants to determine how often the substance is identified, at what levels and if a standard should be established to provide appropriate public health protection. Most recently, the federal government has phased out the use of microbeads in personal care products.

Effective removal of pollutants varies based on the type of chemical and individual treatment system. Current wastewater treatment systems and drinking water plants are not designed to remove many of these new and emerging pollutants which can accumulate in waterways and cause harm. Efforts should be taken to reduce environmental impacts from emerging contaminants through safe disposal; reuse or recycling; the use of technologies or best management practices; product redesign or discontinued use.

Goal Michigan's Water Resources are Clean and Safe			
Outcome: Surface and Groundwater are Managed to Support Sustainable Human Uses and Ecological Function			
#	**Recommendation**	**Implementation Metric**	**Lead Actor**
1	Protect source water (both groundwater and surface water) areas by: • Assuring the remediation of soil and groundwater is protective of source water and where source water is contaminated; provide alterative water to protect public health. • Identifying and diligently protecting source water protection areas. • Assisting well owners with identifying potential water well vulnerabilities. • Focusing resources on contamination sources with the highest potential for causing contamination of drinking water supplies, including chemical storage facilities. • Enhancing the drinking water geographic information system database and making information available across all state of Michigan programs and to state and local public health department environmental health personnel. • Supporting mapping of local groundwater conditions in partnership with well contractors and others who collect groundwater information.	By 2020, address IT security issues, such as firewall and server capacity, to make information publically available. By 2020, develop educational materials to encourage residents with private drinking water wells to test new wells prior to use for nitrates and arsenic and to test wells prior to sale or transfer for bacteria, nitrates and arsenic. By 2020, develop an interface to effectively and efficiently track and monitor for groundwater contamination, and implement data tracking.	MDEQ, MDHHS, Local health departments

#	Recommendation	Implementation Metric	Lead Actor
2	Long-term funding is needed to continue to enhance source water protection programs at the state and local level, provide for alternative water supplies (i.e. bottled water for temporary use and replacement wells or new municipal connection for a permanent long-term use) and remediate contamination to protect surface and groundwater sources.	By 2017, secure long-term funding to continue and enhance source water protection programs at the state and local level, provide alternative water supplies, and remediate contamination to protect surface and groundwater sources.	MDEQ, Legislature
3	Establish uniform inspection requirements for residential wells, including testing wells for nitrates, bacteria and arsenic.	By 2020, implement a statewide requirement for periodic inspections of drinking water quality.	MDEQ, Legislature
4	Develop a plan for aquifer protection that addresses geothermal construction and proper abandonment of wells.	By 2016, convene a stakeholder workgroup to develop draft legislation to regulate closed loop geothermal construction. By 2020, develop educational materials for community water systems and local health departments to increase plugging rates of abandoned wells when municipal water mains are extended.	MDEQ, Legislature
5	Develop and implement a uniform statewide sanitary code that is flexible and provides standards for site suitability based on risk.	By 2019, pass legislation establishing a uniform statewide sanitary code.	MDEQ, MDHHS, Local health departments, NGOs, Legislature
6	Establish a long-term sustainable funding source to support on-site wastewater programs at the state and local levels and to assist financially distressed owners of private on-site wastewater systems with repair and replacement costs.	By 2020, secure a long-term funding source to complete an inventory and assessment of private, single-family home water supplies and all septic systems and to assist distressed owners. By 2025, every county health department has an inventory and assessment of private, single-family home water supplies and all septic systems.	MDEQ, MDHHS, Local health departments, Legislature
7	Establish inspection requirements for existing residential on-site wastewater systems.	By 2020, implement a statewide requirement for periodic inspections of on-site septic system performance for properties with on-site wastewater systems.	MDEQ, MDHHS, Local health departments, Legislature
8	Develop marketing and education campaigns and outreach tools directed at homeowners' on-site wastewater management and maintenance and funding opportunities to assist with repair and replacement.	By 2020, increase the number of entities implementing outreach campaigns directed at homeowners on septic management.	NGOs, Local units of government, Tribal governments

#	Recommendation	Implementation Metric	Lead Actor
9	Secure a long-term funding source to accelerate the cleanup of legacy contaminated sites and support redevelopment.	By 2027, close and remove 7,500 sites from the 201 Facilities Inventory, National Priority List, Leaking Underground Storage Tank Site database and designated Areas of Concern.	MDEQ, MDHHS, Legislature
10	Implement a spill prevention and response strategy that includes an incident command approach and a communication strategy to prevent, prepare for and respond to environmental disasters and chemical releases.	By 2017, complete implementation of Michigan Petroleum Pipeline Taskforce recommendations.	MDEQ, MDNR, MDARD, Michigan State Police, DTMB, federal agencies, pipeline operators
11	Implement a real-time drinking water monitoring network for the Huron-Erie Corridor.	By 2018, develop and implement a sustainable real-time drinking monitoring network for the Huron Erie Corridor.	Local units of government, MDEQ, Universities, Provincial governments, Private industry
12	Establish research priorities for emerging pollutants of concern in partnership with Michigan's research universities and federal agencies and to: • Better understand potential ecological and human health impacts • Adapt monitoring protocols to detect concentrations, fate and transport • Recommend standards for protection of human health and the environment • Develop technologies to remove such pollutants from manufacturing processes	By 2017, increase the number of evaluations and risk assessments completed, new standards developed, and monitoring protocols developed.	MDEQ, MDHHS, Universities, Federal agencies
13	Expand and promote use of comprehensive programs that include public education and collection programs to encourage proper disposal of unwanted and unused pharmaceuticals, personal care products and other hazardous wastes to remove these products from the waste stream and the environment.	Long-term funding is secured to ensure communities can continue collection programs and properly dispose of household contaminants, into the future.	State agencies, Local units of government, Tribal governments

INVEST

in water infrastructure

Sound and modern infrastructure is vital to the health and well-being of people of Michigan. The state's infrastructure – roads, commercial ports, drinking water systems, sewer systems, energy plants, transmission systems, dams and recreational facilities – form the backbone of the state's economy and promote vibrant communities. Therefore, we must preserve, maintain and improve the state's infrastructure now and in the future.

All water withdrawn from the Great Lakes, groundwater, rivers, and lakes for any purpose passes through some form of water infrastructure. Water infrastructure is an elaborate and complex system and network of pumps, pipes and treatment systems that collects, treats, conveys and discharges water, wastewater and stormwater.

A functioning water infrastructure system keeps the state running. Despite its importance, one of the biggest challenges facing communities and metropolitan areas is that water infrastructure systems are aging and deteriorating, requiring more financial resources than are available. The underfunding of public infrastructure, lack of adequate long-term focus around asset management planning and prioritization, declining population and recent economic conditions in the state has contributed to a crisis situation for some communities. During the development of the Water Strategy, the Flint water situation occurred. While the details are still under investigation, there are important issues that the public and leaders in Michigan need to examine with regard to drinking water infrastructure, including the replacement of lead service lines, ensuring access to affordable water for drinking and sanitation and investments in water infrastructure. The need for leadership and support of investments in water infrastructure improvements and programs that protect water resources is critical to public health and water quality. It is a fundamental responsibility of government to ensure its citizens' accessibility to safe drinking water. The citizens of Michigan expect safe, cost-effective and sustainable access to water, sewer, wastewater treatment and drainage services.

Moving beyond traditional approaches and investing in more integrated water infrastructure systems that involve the implementation of energy efficiencies, technologies, and a combination of grey and green infrastructure as well as implementation of programs to provide access to affordable water for drinking and sanitation is necessary to maintaining clean water, healthy ecosystems, and protecting public health.

Goal

Michigan invests in infrastructure and supports funding to maintain clean water and healthy aquatic ecosystems

Outcome

People support investment of public and private funding of Michigan water resources

Measures of Success

- The citizens of Michigan will have cost effective and sustainable access to safe water, sewer, wastewater treatment and drainage services.
- Outcome-based asset management plans are implemented and progress is achieved toward true cost of service for water utilities.
- Sustained funding is in place to implement the Water Strategy and achieve the goals of the Strategy.

Improve Understanding of the True Cost of Water

Most people think of their water bill as the cost they pay for water. But in reality, water, as a natural resource, is actually free for any purpose and for any amount used by any entity, public or private, as long as its use does not degrade the resource. While water as a resource may be free, there are responsibilities and costs associated with paying for the delivery and treatment of water and for managing and stewarding Michigan's water resources to ensure that water is of high quality and available for human uses.

Through their water bills, Michiganders pay for the infrastructure to deliver safe drinking water, treat and condition water, carry away and treat waste, for operating costs (like energy), and infrastructure maintenance. On average, Michigan residents pay approximately .075 of a cent per gallon of drinking water and wastewater combined.[3] Those outside the area of a municipal water supply system pay for well construction, treatment if necessary, and the energy used to pump and supply water to the tap.

For municipal water systems, water's cost is determined by volume-based pricing that allows the collection of revenues to pay for infrastructure and the operations used to deliver, convey, and treat water. There is often a lower per unit, usually gallons, fee on water for higher volume users and amounts. Water rates are commonly skewed in such a way that users pay less as volumes rise, because the price is pegged to infrastructure costs and not to the value of water itself. In some instances, this can act as a complicating factor when trying to achieve water use reduction or conservation, as conservation equates to lower revenues for municipalities. A customer's use of less water does not necessarily or directly equate to lower operational costs of infrastructure or lower rates. There is still a substantial cost to have safe drinking water delivered at adequate quantities and pressures whenever the tap is opened and to have fire protection available at the curb within the reach of a standard fire hose in event of an emergency.

Water rates have historically been low and water both plentiful and affordable in most Michigan communities except for some metropolitan areas. Flint's water issues, Detroit's water shutoffs, the loss of urban population in other communities, and an overall increase in domestic water conservation has put a sharper focus on water rates, access, affordability, and the ability of communities to fund aging infrastructure costs. The American Water Works Association has evaluated affordability models used for resources like energy and other cities (including Cincinnati and Philadelphia) have established water affordability programs. More recently, the Detroit City Council has charged a Blue Ribbon Committee with developing a water affordability plan for the City of Detroit; however, in Michigan, we are just starting assessments of shut-off practices or policies that relate to affordability and water access for human use. Rate structures that provide flexibility in rates to ensure financially distressed customers have access to affordable water for drinking and sanitation that still account for actual cost of service, investments in infrastructure and promote individual conservation and responsibility are needed.

Michigan has a long history of not putting a commodity price on water, thus keeping water a free resource, and an important element of the state's economic and social well-being and stability. During public outreach for the Water Strategy, many residents suggested either putting a fee on water for all or some groups of

water users – in its simplest form, a per gallon charge for water as it comes from the environment. Some suggested that only some types of water users should pay a per gallon fee for withdrawing water. Others suggested all users should pay a surcharge or a per gallon fee for the use of water, regardless of the user or purpose. Given that Michigan's citizens and businesses withdraw more than 4.2 trillion gallons per year, equivalent to the amount of precipitation that falls on the U.S. per day, even a tiny surcharge or access charge would add up quickly. Conversely, some argued that adding a price to water, even as an access charge versus a price on water per se, would commodify the resource, when it has historically been a public good or a public trust resource. The economic logic may make sense in the abstract, but it does not currently fit the culture and history of water and water use in the state.

Maintaining the ability to manage and ensure the sustainability of water resources of Michigan and the Great Lakes is of utmost value to the state and the region, and even though a revenue stream could be created from a volume or access charge on water, the values potentially compromised under this scenario are too great to lose. However, there is still a compelling and growing need for investments in water and water infrastructure to pay for collection, treatment, and delivery through an elaborate network of pumps, pipes and treatment systems.

To address the gap between actual investment need and public perception of that need, Michigan should launch a public education campaign to improve residents' understanding of the economic, environmental and social benefits of clean water, linking the investments necessary to achieve the benefits. If the public wants clean beaches and good water quality – and they say they do – public support of water infrastructure

investments is critical. While we do not seek to facilitate a volumetric surcharge on water access, if that is something the public would ultimately support, then it would add to the options for funding long-term infrastructure and desired outcomes described in the Strategy.

Invest in System Approaches to Address Water Infrastructure

One of the biggest challenges facing communities is aging, deteriorating infrastructure systems with more operational needs than financial resources to meet them. Poor infrastructure affects public health, degrades the value of water, results in costly efforts to mitigate impacts and creates or increases drag on the economy. Therefore, Michigan must develop and implement a modern approach to its future infrastructure investments by developing a comprehensive, coordinated and effective long-term vision for infrastructure systems looking to experts and leaders from across the state that are committed to Michigan's future.

On March 10, 2016 Governor Snyder created the 21st Century Infrastructure Commission whose task is to develop a comprehensive strategy designed to apply this approach to Michigan's entire infrastructure, including those components related to water use. The Commission will serve in an advisory capacity to the Governor and the state and will be comprised of representatives from various government agencies, non-profit organizations and businesses who have particular expertise in infrastructure development. Their task is to submit a report by November 30, 2016 detailing a comprehensive infrastructure vision for Michigan, including the use of an all-inclusive infrastructure management system comprised of, among many components, prioritized long-term and short-term capital planning, joint state and local government evaluation of planning and infrastructure needs and recommended funding mechanisms. The goals and recommendations of this chapter are intended to coincide with the vision developed by the Commission.

In an ideal world, rates would reflect true cost of service and consider operation and maintenance costs as well as long-term capital investment needs. Water infrastructure systems are complex networks and are best met by modern data-driven approaches to asset management. Asset management planning, performed properly, would support municipalities' efforts to optimize future costs and collect revenues sufficient to operate and maintain the system. Asset management planning principles should be applied including identifying the data that is required for successful delivery and operation of an asset management program; determining whether the relevant data is available (condition, inventory, financials); and developing and implementing a plan to obtain any required data that is not yet available.

Since 2013, some large municipal wastewater treatment plants have been required to develop an asset management plan as part of their National Pollutant Discharge Elimination Standard (NPDES) permit; however, this requirement doesn't apply to all water utilities. Asset management planning that includes more efficient use of resources can result in cost efficiencies that can be used to address capital costs while keeping rates affordable.

In addition, a more integrated systems approach to managing and maintaining water infrastructure can also improve water management, reduce energy costs and result in savings for communities as opposed to investing in traditional methods which typically have higher capital investment costs. Communities can realize cost efficiencies to manage water infrastructure systems and to meet the investment needs of the future by increasing efficiencies in the delivery and treatment of water through implementation of energy efficiency measures, the use of technologies and a combination of grey and green infrastructure. Investments in green infrastructure can extend the life of grey infrastructure systems and support long-term cost benefits. Integrating infrastructure improvements into community planning and economic developing planning to align water infrastructure projects with other community and economic development projects to take place together rather than independently will lead to significant long-term cost savings. For example, roadway projects should also include other needed infrastructure upgrades such as water, sanitary and stormwater.

If communities continue to use traditional methods to manage infrastructure, conservative estimates range in the billions to improve stormwater, drinking water and wastewater management systems over the next 20 years. Although a large majority of these costs are not the responsibility of federal or state government, the state needs to implement a long-term strategy to sustain state water infrastructure and state water programs, including funding to maintain

critical regulatory oversight programs, water quality monitoring and provide assistance to communities to local water infrastructure. In addition, the state should explore a variety of options to close the widening gap between existing funding sources and future revenue needs. These include incentivizing asset management planning; state bonding and borrowing options; dedicated capital and trust funds; public-private partnerships; insurance and leveraging; private equity; and service area consolidation. Without adequate funding, Michigan's economy, aquatic ecosystems and quality of life will be at risk.

Support Use of Stormwater Utilities

Many urban communities face challenges with managing stormwater and financing the costs of stormwater infrastructure. Urban community leaders have expressed concern about the lack of sustained funding mechanisms to maintain and replace aging infrastructure. The Michigan Supreme Court's interpretation of the Lansing stormwater case, known as the Bolt Decision, requires that communities ask voters before imposing a tax to fund improvements in stormwater infrastructure. The Court ruled that the stormwater service charge imposed by Lansing was unconstitutional and void on the basis that it was a tax for which voter approval was required and not a valid use fee. The Court established three criteria for distinguishing between a fee and a tax:

1. A user fee must serve a regulatory purpose rather than a revenue-raising purpose
2. A user fee must be proportionate to the necessary costs of the service
3. A user fee must be voluntary—property owners must be able to refuse or limit their use of the commodity or service

There is no real structural impediment to a stormwater utility. However, urban community leaders have encouraged the legislature to draft legislation to support the use of storm water utilities in Michigan and address the issues raised in *Bolt v City of Lansing*. Specifically, legislation is needed to provide more guidance and support to communities interested in seeking voter-approved revenues to implement federal and state requirements.

Community leaders have also asked for the evaluation and support for alternative financing approaches and legislative options to dedicate a funding stream for stormwater management infrastructure.

Develop an Enterprise Budget for Water

The State needs to complete an enterprise budget to more fully understand the complex relationships between water, infrastructure needs and funding across all entities, including state agencies, federal agencies, local municipalities, drain commissioners and inter-county drain boards. An enterprise budget is a theoretical budget – not a responsibility budget – that portrays revenue and expenditures regardless of agency or governmental unit. The four principle revenue sources related to water in the state – federal, state and local revenues and fees, and private revenues – should be included in the enterprise budget. This budget will also assist in understanding how to maximize the sustainability of the funds used to support water infrastructure and state programs.

A recent analysis of the enterprise budget for water utilities by KPMG identified an opportunity to improve efficiencies and create opportunity for cost-savings for water utilities. The analysis identified differences between the volumes of drinking water treated versus the volumes ultimately billed to customers. One large municipality reported that for drinking water, the billed volumes across the drinking water system were approximately 10% lower than treated volumes of water, implying a 10% system loss, unbilled use and/or measurement error.[4] Anecdotally, such a difference is not unusual and presents a significant unrecovered cost for municipalities and a significant opportunity for cost saving, given the right approach. The efficiency and cost savings that could be realized by the recovery of unbilled water represents an increase in annual net revenue that could be used to service debt payments on infrastructure investments.

Aging infrastructure like this leaky pipeline contributes to system losses and unrecovered cost for municipalities.

Goal: Michigan Invests in Infrastructure and Supports Funding to Maintain Clean Water and Healthy Aquatic Ecosystems			
Outcome: People Support Investment of Public & Private Funding of Michigan Water Resources			
#	**Recommendation**	**Implementation Metric**	**Lead Actor**
1	Utilize pricing & funding strategies to support infrastructure improvements while allowing for water conservation.	By 2020, increase the number of communities that have pricing and funding strategies as part of their asset management plans to support infrastructure improvements over a baseline established in 2016.	Local units of government, Water utilities
2	Evaluate current community practices regarding providing water to financially distressed customers, including sustainable assistance programs and individual responsibility, to ensure all citizens have affordable access to water for drinking & sanitation.	By 2017, increase the number of communities that have practices in place to ensure financially distressed customers have access to water for drinking and sanitation over a baseline established in 2016.	Local units of government, Water utilities
3	Implement comprehensive communication strategies across water providers to build customer support for water infrastructure investments that link the relationship between investments in water infrastructure and clean water and the benefits maintained infrastructure provides.	By 2017, develop guidance and provide water utilities with communication tools and best practices to educate its customers on the relationship between water rates, investments in water infrastructure, and clean water.	Water utilities, NGOs
4	Incentivize and require asset management planning for all public water utilities that includes more efficient use of resources.	By 2018, all community water suppliers serving more than 1,000 people shall provide in their general plan a system to inventory and assess criticality of assets, state level of service goals, capital improvements plan for 5-year and 20-year planning periods, and a funding structure providing sufficient resources for implementing an asset management plan. By 2020, require all major NPDES-permitted dischargers to develop and implement asset management planning for each system.	MDEQ
5	Establish sustainable funding mechanisms through the 21st Century Infrastructure Commission to achieve Water Strategy goals, including water infrastructure management.	By 2020, implement a long-term funding strategy to achieve goals of the Water Strategy and support existing State of Michigan Quality of Life Agency (MDEQ, MDARD, & MDNR) programs and policies. By 2020, Implement recommendations from the 21st Century Infrastructure Commission.	State agencies, Legislature
6	Implement legislation that supports the use of stormwater utilities in Michigan and addresses issues raised in *Bolt v City of Lansing*.	By 2018, support through legislation the efforts to local communities to establish stormwater utilities to comply with the Bolt decision.	MDEQ, Legislature, NGOs, Local governments
7	Develop an enterprise budget to better understand the complex relationships between managing water, infrastructure needs & funding.	By 2016, develop an enterprise budget for water to inform the long-term funding strategy.	MDEQ

Acronyms and Definitions

AIS – Aquatic Invasive Species - An invasive species is defined as a species that is not native and whose introduction causes, or is likely to cause, economic or environmental harm or harm to human health.

AOC – Areas of Concern - Federally designated places where numerous beneficial uses of the areas (fishing, swimming, hunting, drinking water) have been impaired due to historical contamination.

CAWS – Chicago Area Waterways System

CMI – Clean Michigan Initiative

DDT – A commonly used pesticide (Dicholorodiphenyltrichloroethane) that was banned in 1972 that has contributed to fish consumption advisories in the Great Lakes ecosystem.

Evapotranspiration – How water is transferred from land to the atmosphere by evaporation from the soil and transpiration from plants.

Flashiness – The ability of a stream to quickly reach flood stage after a snowmelt or rainfall event.

Ecosystem – The complex set of relationships among living resources and their habitat

Food web – The system of interlocking and interdependent food chains

GLITTH – Great Lakes International Trade and Transport Hub

GLRI – Great Lakes Restoration Initiative

GLSLCI – Great Lakes and St. Lawrence Cities Initiative

Grey infrastructure – Impervious surfaces like roads, buildings, and parking lots which prevent rainfall from penetrating the soil.

Grey water – The relatively clean wastewater from sinks, baths, and washing machines.

HAB – Harmful Algal Bloom - Algal blooms that produce concentrations of harmful toxins such as blue green algae or cyanobacteria.

Impaired waters – Under section 303(d) of the Clean Water Act, states, territories, and authorized tribes are required to develop lists of impaired waters. These are waters that are too polluted or otherwise degraded to meet the water quality standards set by states, territories, or authorized tribes.

Implementation metric – A tactical metric to measure progress toward accomplishing the recommendation.

LARA – Michigan Department of Licensing and Regulatory Affairs

MAEAP – The Michigan Agriculture Environmental Assessment Program is an innovative, proactive, and voluntary program that helps farms of all sizes and all commodities voluntarily prevent or minimize agricultural pollution risks administered by the Michigan Department of Agriculture.

MDEQ – Michigan Department of Environmental Quality

MDARD – Michigan Department of Agriculture and Rural Development

MDHHS – Michigan Department of Health and Human Services

Measures of Success – A measure of the improvement in environment, social or economic conditions overtime as a result of multiple actions.

MEDC – Michigan Economic Development Corporation

MDNR – Michigan Department of Natural Resources

Nonindigenous – Fish or wildlife not native to a place.

Nonpoint source pollution – Pollution that comes from snowmelt and stormwater that flows over impervious surfaces, collecting pollutants, and eventually drains into a body of water.

NPDES – The National Pollutant Discharge Elimination System (NPDES) permit program controls water pollution by regulating point sources that discharge pollutants into waters of the United States.

NREPA – Natural Resources and Environmental Protection Act

Outcomes – The desired final results.

PBT – Persistent Bio-accumulative Toxin

PCB – Polychlorinated Bi-Phenyl

Point source pollution – Pollution from industrial and sewage treatment plants that is directly deposited into the water.

Redevelopment Ready Communities Program – A statewide certification program that helps communities adopt innovative redevelopment programs and become economically competitive.

Stormwater – Water from precipitation events that runs off impervious surfaces and collects pollutants.

Sustainable – Able to be maintained indefinitely without significant depletion of resources.

URC – University Research Corridor - The formally created research cooperative comprised of the University of Michigan, Michigan State University and Wayne State University.

U.S. EPA – United States Environmental Protection Agency

Water literacy principles – The understanding of water's influence on the individual and the individuals influence on water. An example of a water literacy principle is that bodies of fresh water are connected to each other and to the world.

Watershed – The area of land from which water drains into a receiving body of water.

WHO – World Health Organization

WLEB – Western Lake Erie Basin

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