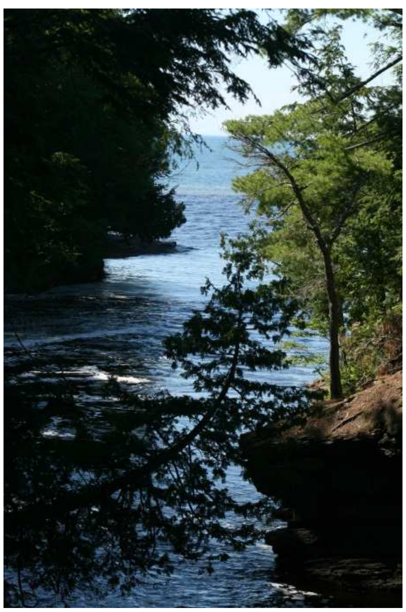
MI/DEQ/WRD-16/004

Michigan Surface Water Monitoring Strategy Update 2017









Michigan Department of Environmental Quality
Water Resources Division

January 2017

Acknowledgements:

Great appreciation is extended to contributing staff of the Michigan Department of Environmental Quality's Water Resources Division and Office of the Great Lakes, for their hard work and assistance in the development of this Monitoring Strategy Update.

Title page images provided by Dawn Roush. Images within the document provided by Dawn Roush unless noted in figure captions.

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List of Acronyms

AIS	Aquatic Invasive Species
AOC	Area of Concern
ATTAINS	Assessment and Total Maximum Daily Load Tracking and Implementation System
BEACH Act	Beaches Environmental Assessment and Coastal Health Act
BEHI	Bank Erosion Hazard Index
BMP	Best Management Practice
BUI	Beneficial Use Impairment
CLMP	Cooperative Lakes Monitoring Program
CMI	Clean Michigan Initiative
CSO	Combined Sewer Overflow
CWA	Clean Water Act
CWF	Clean Water Fund
DDT	Dichloro-diphenyltrichloroethane
DNA	Deoxyribonucleic Acid
FCMP	Fish Contaminant Monitoring Program
FD	Fisheries Division
FY	Fiscal Year
GIS	Geographic Information System
GLEC	Great Lakes Environmental Center
GLRI	Great Lakes Restoration Initiative
GLWQA	Great Lakes Water Quality Agreement
HUC	Hydrologic Unit Code
LAMP	Lakewide Action and Management Plan
LMMCC	Lake Michigan Monitoring Coordination Council
LWQA	Lake Water Quality Assessment
MDARD	Michigan Department of Agriculture and Rural Development
MDEQ	Michigan Department of Environmental Quality
MDHHS	Michigan Department of Health and Human Services
MDNR	Michigan Department of Natural Resources
mg/kg	Milligrams per Kilogram
mg/l	Milligrams per Liter
MiCorps	Michigan Clean Water Corps
MiRAM	Michigan Rapid Assessment Method
MiSWIMS	Michigan Surface Water Information Management System
NARS	National Aquatic Resources Survey
NCCA	National Coastal Condition Assessment
ng/kg	Nanograms per Kilogram
ng/l	Nanograms per Liter
NHD	National Hydrography Dataset
NLA	National Lakes Assessment
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source
NREPA	Natural Resources and Environmental Protection Act
NRSA	National Rivers and Streams Assessment
NTU	Nephelometric Turbidity Unit
NWCA	National Wetlands Condition Assessment
OIALW	Other Indigenous Aquatic Life and Wildlife
P-22	Procedure 22
P-51	Procedure 51
PAH	Polycyclic Aromatic Hydrocarbon

PBC	Partial Body Contact
PBDE	Polybrominated Diphenyl Ethers
PCB	Polychlorinated Biphenyl
QAPP	Quality Assurance Project Plan
QMP	Quality Management Plan
QPCR	Quantitative Polymerase Chain Reaction
RMN	Regional Monitoring Network
SSO	Storm Sewer Overflow
STORET	Storage and Retrieval
SWAS	Surface Water Assessment Section
TBC	Total Body Contact
TMDL	Total Maximum Daily Load
ug/L	Micrograms per Liter
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WCMP	Water Chemistry Monitoring Program
WQS	Water Quality Standards
WQX	Water Quality Exchange
WRD	Water Resources Division

Executive Summary

"What do you want Michigan and Michigan's water resources to look like and do over the next generation?" That is the question posed to Michiganders in multiple forums during the development of the Michigan Department of Environmental Quality (MDEQ) document, "Sustaining Michigan's Water Heritage," which outlines a 30-year vision shaped by a desire for high-quality, accessible water resources protected by and for present and future generations (MDEQ, 2016a).

The overwhelming message: ***Michigan citizens care deeply about Michigan's Great Lakes, rivers and streams, inland lakes, and wetlands.***

This response is not unexpected. After all, long before we heard of Pure Michigan, the citizens of this Great Lakes state supported a clean Michigan – the Clean Michigan Initiative (CMI) $675 million bond passed by voters in 1998 to clean up, protect, and enhance Michigan's environmental quality, natural resources, and infrastructure. The bond included a Clean Water Fund (CWF), of which $45 million was set aside for water quality monitoring. And now, these CMI-CWF dollars that support many Water Resources Division (WRD) monitoring activities are coming to their end. The CMI-CWF is expected to be exhausted by the end of fiscal year (FY) 2018. The CMI-CWF funds were intended to be spent at a rate of $3 million annually over 15 years; however, WRD staff has worked diligently to makes these funds last as long as possible. When the final dollar is spent, Michigan will have seen these funds last for at least 18 years.

Water quality monitoring is as critical as the water resources it protects. The combination of CMI-CWF, federal funding, and other state funding (when available) has led to several monitoring-based accomplishments, including:

- Michigan is the first state to monitor beaches statewide with rapid testing equipment that produces same-day results.
- Fish tissue trends show what and where fish are safe to eat in Michigan's inland lakes, rivers and streams, and Great Lakes.
- Wildlife monitoring has helped delist Areas of Concern (AOC).
- Statewide monitoring of rivers and streams shows how many river miles meet water quality standards (WQS) and where efforts are needed to protect aquatic life.

These are just a few actions that WRD staff has taken to protect human health, aquatic life, and other designated uses of the surface waters of the state. The WRD recognizes comprehensive water quality monitoring is necessary to have healthy people, ecosystems, communities, and economies (MDEQ, 2016a). Many efforts require long-term, steadfast status and trend monitoring, while others, such as emerging issues, require the WRD to be nimble and take action accordingly. Currently, one major emerging issue is harmful algal blooms, which threaten human health – most famously the western basin of Lake Erie in 2014 when a massive bluegreen algae bloom produced toxins that forced the shutdown of Toledo's drinking water supply, impacting over 400,000 residents in Ohio and southeast Michigan. The WRD began monitoring for microcystin, a known toxin that can be produced by certain species of algae, in 2012 on western Lake Erie beaches. In 2015, monitoring microcystin and other algal toxins in inland lakes was added to the inventory of efforts to research when and why toxins are sometimes produced.

"A Strategic Environmental Quality Monitoring Program for Michigan's Surface Waters," written in 1997 (MDEQ, 1997), was the first comprehensive account, or Monitoring Strategy, to document the four monitoring goals of the WRD, which are:

- Assess the current status and condition of waters of the state and determine whether WQS are being met.
- Measure spatial and temporal water quality trends.
- Evaluate the effectiveness of water quality restoration and protection programs.
- Identify new and emerging water quality problems.

In 1997, funding and staffing resources devoted to water quality monitoring had been dropping substantially for almost a decade. This led to a decline in monitoring efforts that, in turn, led to numerous reports criticizing the MDEQ for lacking an adequate monitoring program (Michigan Environmental Science Board, 1993; Michigan Office of the Auditor General, 1995; Michigan Mercury Pollution Prevention Task Force, 1996). As a result of these resource constraints, the first Monitoring Strategy was written as a "wish list" that built on existing monitoring and identified activities and resources needed to establish a comprehensive, state-of-the-art water quality monitoring program.

The approval of the CMI bond in 1998 and its $45 million of CWF dollars set aside specifically to support the Monitoring Strategy resulted in an increase of approximately $3 million per year for surface water quality monitoring, which led to a robust monitoring program. An update to the Monitoring Strategy was written in 2005 to reflect the increased monitoring efforts; evaluate the effectiveness and continued relevance of ongoing monitoring activities; and identify potential opportunities for future monitoring. Program gaps, possible improvements, and resource needs were discussed with timelines for their assessment.

The WRD has fulfilled many monitoring needs since 2005, due in large part to the CMI-CWF. Pilot projects to fill data gaps have become fundamental monitoring activities, additional projects are underway, and new statistical approaches have become standard practices for statewide and regional monitoring. This document is the most recent compilation of WRD monitoring efforts in Michigan's surface water and addresses that, in the last decade, monitoring efforts have developed and grown with the evolving nature of program needs, technology, and technical guidance/science.

This document is divided into two sections, Section 1 provides an overview of WRD monitoring elements: objectives; core and supplemental indicators; data quality, assessment, reporting, management; programmatic evaluation; and general support and infrastructure planning. Section 2 addresses the WRD monitoring efforts in each of Michigan's water body types: Great Lakes, rivers and streams, inland lakes, and wetlands. Both sections outline ***gaps***, which can be defined as: (1) where the WRD does not have the necessary methodologies or procedures to fully implement the Monitoring Strategy; (2) where limitations exist due to staffing and or budgetary issues; or (3) where the adaptive management process calls for an evaluation of monitoring approaches to determine whether newer science techniques and technologies exist to better evaluate the goals of the Monitoring Strategy. See Appendix A for these gaps listed by water body type.

Please note our Monitoring Strategy continues to be an ongoing, iterative process. As such, we welcome comments and input from a broad array of stakeholders, including agency managers and staff (federal, state, and tribal), local governments, academia, the private sector, environmental organizations, and the general public. This document serves as a current benchmark and does not preclude the WRD from adding, eliminating, or modifying water quality monitoring activities as appropriate based on evolving needs and stakeholder input.

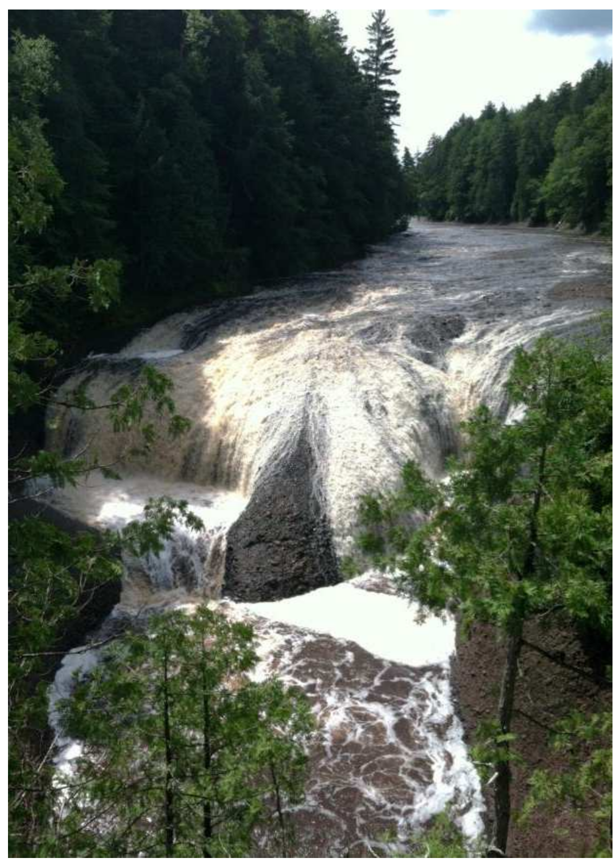
Section 1: Monitoring Strategy Update

Introduction to Monitoring Michigan's Water Resources

Monitoring is fundamental to understanding the environment around us. It tells us the what, where, and when of environmental issues. Without water quality monitoring, we would not know what pollutants are in a water body, where you can eat the fish, and when the beaches are safe for swimming. Answering these questions are a few of the ways staff of the MDEQ, WRD, reach the goals of this Monitoring Strategy. Monitoring the water quality of Michigan's Great Lakes, rivers and streams, inland lakes, and wetlands is an essential component of the WRD mission.

Michigan is surrounded by four of the five Great Lakes and 3,288 miles of Great Lakes shoreline. Residents and the out-of-state visitors who take 4.1 million trips to Michigan (2014 estimate by Longwood International [2015]) no doubt visit these lakes for recreation and pure aesthetic enjoyment. We visit the Great Lakes to relax on the more than 600 public beaches that are nested along some of our 225,000 acres of sand dunes.

But Michigan's water resources do not stop at the shoreline. More than 75,000 miles of rivers and streams run through Michigan. Of these thousands of miles, the Michigan Department of Natural Resources (MDNR) reports that over 12,000 miles are coldwater trout streams. Since 1970, the MDNR has designated 2,091 river and stream miles along 16 rivers as Natural Rivers under the authority of Part 305, Natural Rivers, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA).



The Black River, Gogebic County

Michigan rivers are also known for their picturesque waterfalls, like the Black River corridor in Gogebic County, which is part of the United States Forest Service, National Scenic Byway System. And more than 400 miles away from this waterfall, the Huron and Clinton Rivers provide a unique escape from their urban setting in southeast Michigan, with their 13 Metroparks that cover nearly 25,000 acres. Almost 9 million people visit the Metropark system each year, according to Huron-Clinton Metropolitan Authority's Metropark Web site, www.metroparks.com.

Michigan's inland lakes are extremely valuable. It is often reported that Michigan has 11,000 lakes. The United States Geological Survey (USGS) National Hydrography Dataset (NHD) shows there are actually 46,000 inland lakes and reservoirs in Michigan with a minimum size of

0.1 acres. To clarify by size, Michigan has 26,266 lakes greater than one acre; 6,537 lakes greater than ten acres; 1,148 lakes greater than 100 acres; 98 lakes greater than 1,000 acres; and 10 lakes greater than 10,000 acres (Breck, 2004).

The water bodies that work quietly behind the scenes are our wetlands. They are a large reason the rest of our water resources are what we likely think about when we hear a Pure Michigan campaign. They provide excellent waterfowl and fish nursery habitat, flood and erosion control, groundwater recharge, water quality benefits, and also provide their own aesthetic beauty to Michigan.

It is important to note that groundwater is an important water resource, and while it can impact surface water, it is not covered in this document. Currently, the WRD has awarded a federal Clean Water Act (CWA) Section 205(j) pass-through grant to Western Michigan University for the development of a groundwater monitoring strategy. This grant is in progress and is overseen by Groundwater Permits Unit staff in WRD's Permits Section. Water Resources Division will determine if and how surface water and groundwater monitoring efforts should be coordinated when the strategy is complete.

Table 1 provides some statistics for Michigan's surface water resources – resources that exist through the relatively recent geologic formations underfoot. Glacial processes laid the framework for today's topography, hydrology, and abundant groundwater resources in Michigan. Michigan's surficial geology is dominated by continental glaciation (similar to present day Greenland). Landscapes (e.g., glacial outwash plain, end moraine, ground moraine) tell us whether a water body is well drained, poorly drained, or highly erosive. Moraines with underlying till comprise most of Michigan's geology with glacial outwash plains providing the foundation for most of Michigan's river valleys. Figure 1 shows the geologic formations of Michigan and provides a clear view of our landscape differences.

Table 1. Michigan statistics. Taken from the MDEQ "Assessment Methodology," Chapter 4 of the 2014 Integrated Report (MDEQ, 2014a).

Michigan Data	Statistic	Source
State surface area	96,760 square miles	Sommers, 1977
Population	9.9 million	United States Census Bureau 2010 estimate
Surface Water Resources		
Great Lakes – including bays and Lake St. Clair	42,167 square miles (~45% of total Great Lakes area)	USGS NHD 1:24,000 scale
Rivers and streams (including Connecting Channels)	76,419 river miles	USGS NHD 1:24,000 scale
Inland lakes and reservoirs with surface area > .01 acre	46,000 covering 870,109 acres	USGS NHD 1:24,000 scale
Wetlands	6,465,109 acres	United States Fish and Wildlife Service National Wetlands Inventory

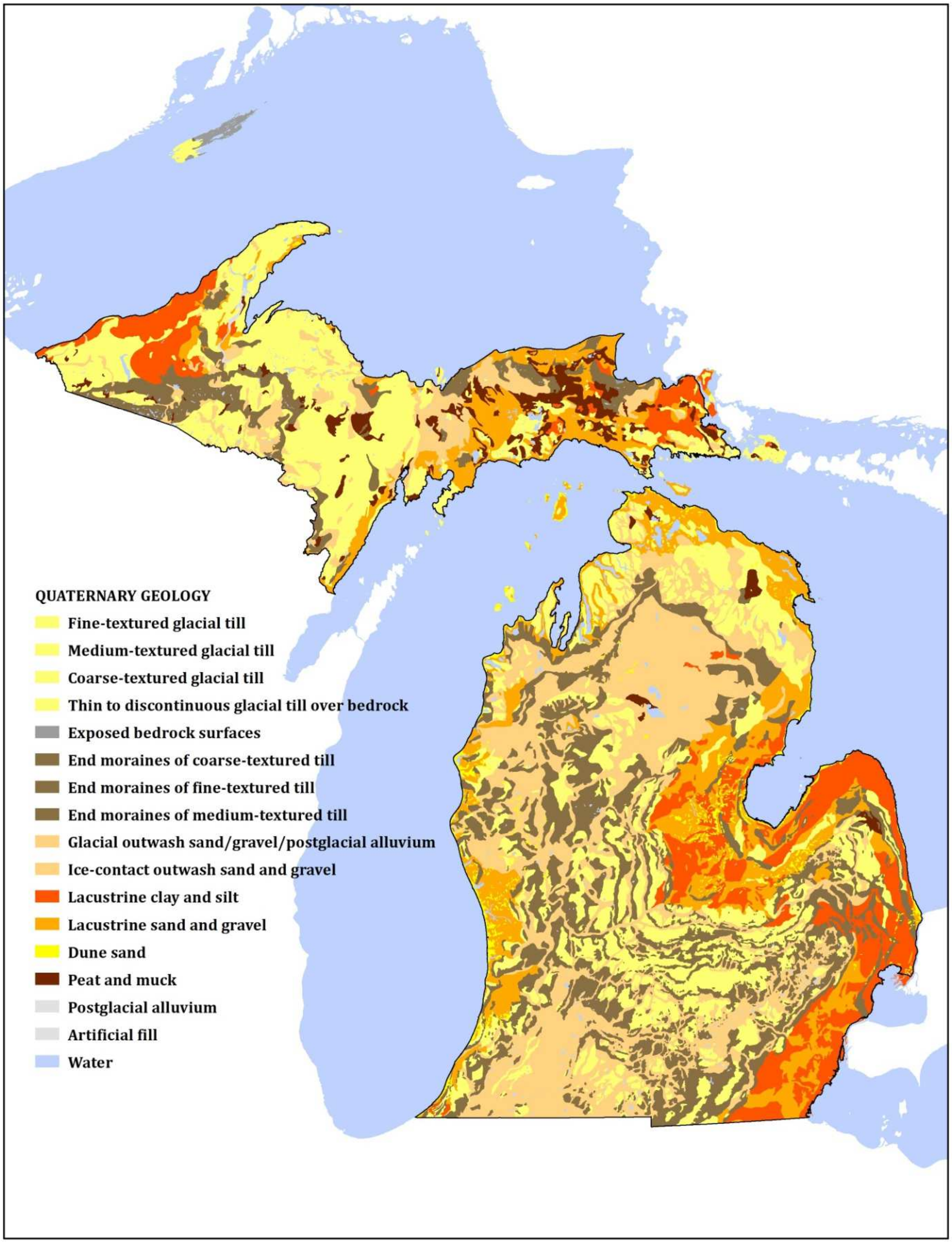


Figure 1. Quaternary Geological Formations of Michigan.

Monitoring Strategy Goals

The goals of the WRD Monitoring Strategy are largely unchanged from those established in 1997. These broad goals are inclusive of the more specific CWA objectives related to monitoring, including support for WQS criteria development, determination of designated use attainment (including causes and sources of impaired water quality), and support of water management programs. The WRD has many monitoring projects that support these CWA objectives, and examples of these projects are shown below under each WRD monitoring goal:

Assess the current status and condition of waters of the state and determine whether WQS are being met.
For all water bodies with monitoring conducted using routine statistical (probabilistic) and/or fixed-targeted assessments as well as special projects, data are collected using methods that assess both the water quality condition and designated use attainment status when applicable. Specific examples include, but are not limited to, all data collected as part of the Water Chemistry Monitoring Program, (WCMP), the Fish Contaminant Monitoring Program (FCMP), Escherichia coli (*E. coli*) monitoring, and biological condition assessment in rivers and streams. Data collected by volunteer groups and other agencies can also be used to make designated use support determinations if they are of sufficient quality and consistent with the WRD's assessment methodology.

Measure spatial and temporal water quality trends.
The WCMP, FCMP, and macroinvertebrate community component of biological assessment in wadeable rivers and streams all contain a component to assess water quality trends. These trend analyses are in relation to values regarding numerical water quality standards (e.g., trends of total mercury in rivers and streams) as well as trends in parameters that relate to narrative water quality standards (e.g., trends of total phosphorus at fixed stations in Saginaw Bay).

Evaluate the effectiveness of water quality restoration and protection programs.
Monitoring data support programs that include, but are not limited to, Total Maximum Daily Load (TMDL) development and implementation, nonpoint source (NPS) evaluations (e.g., success stories), potential point source and water-withdrawal impacts, and WQS studies (e.g., color analysis in inland lakes to support nutrient criteria development). Monitoring efforts also support needs that go beyond WRD programs, including nutrient and algal toxin sampling (e.g., assess concerns in Lake Erie water quality as it relates to human health and Annex Four of the Great Lakes Water Quality Agreement).

Identify new and emerging water quality problems.
Monitoring for new and emerging issues can be conducted as part of routine monitoring (e.g., *E. coli* counts at WCMP probabilistic stations) or through the design of special projects (e.g., harmful algal bloom assessment in inland lakes and beaches).

While the fundamental goals remain the same, the WRD "essential elements" of our monitoring structure have evolved. The nine elements discussed in the 1997 and 2005 documents were: water chemistry, fish contaminants, sediment chemistry, biological condition, wildlife contaminants, bathing beaches, inland lake quality/eutrophication, stream flow, and volunteer monitoring (MDEQ, 1997; MDEQ, 2005a). These remain essential elements today. However, aquatic invasive species (AIS) monitoring represents an obvious need that has grown since our 1997 document, stream geomorphology has become an important aspect to measuring how rivers and streams respond to disturbances, and it would be incomplete to limit the discussion of pathogen monitoring efforts to beaches. In this update, the elements are realigned as follows:

- Water Chemistry
- Beaches and other Recreational Waters (pathogens)
- Biological Condition
- Fish Contaminants
- Inland Lake Quality and Eutrophication
- AIS
- Wildlife Contaminants
- Sediment Chemistry
- Hydrology/Stream Geomorphology
- Volunteer Monitoring

These monitoring elements are the foundation for how the WRD measures the quality of Michigan's surface waters. They are largely accomplished through WRD staff monitoring efforts but also by volunteers, through contracts and grants, and in partnerships with other agencies.

The United States Environmental Protection Agency (USEPA) has indicated states should strive to assess 100% of all water body types for all designated uses. While a laudable goal, the WRD recognizes the resources needed for such comprehensive monitoring that goes toward only one of our monitoring objectives is beyond the ability of any agency. **The WRD is committed to strategic monitoring with adaptive management, recognizing realistic constraints, practical considerations, and knowledge gained over time.** The WRD is involved in extensive monitoring to reach all four goals of our Strategy, from water chemistry to biological indices to contaminants in bald eagle plasma; however, our efforts are resource-limited. There continues to be monitoring gaps, some new and some persistent. These gaps, plus the extensive monitoring activities, are described in this Monitoring Strategy.

Efforts in Michigan's rivers and streams have been strong since the first Strategy was written in 1997, while surface resource monitoring in other water body types has been inconsistent. Today, the WRD is increasing efforts in all surface waters. Beginning in 2014, the WRD piloted a new statewide design to monitor inland lakes through a partnership with the MDNR. The pilot study increased in effort in 2015 and is continuing as routine monitoring. Wetland monitoring activities are growing, with the initiation of a statewide wetland condition status and trend element in 2016.

The WRD has participated in the National Aquatic Resources Survey (NARS), which is administered by the USEPA, since 2009 and has led field sampling for these national assessments in Michigan's Great Lakes, rivers and streams, inland lakes, and wetlands. Participating in the NARS National Coastal Condition Assessment (NCCA) in 2010 was the WRD's first comprehensive effort to assess the nearshore waters of Michigan's Great Lakes. As a result, the WRD is using Section 106 Monitoring Initiative set-aside grant funding to determine whether data collected through the NCCA can be incorporated into Michigan's water quality assessment methodology. And the growth of monitoring efforts in wetlands is in large part due to the National Wetlands Condition Assessment (NWCA).

As time and funding allows, the WRD engages in special projects that address known monitoring gaps, research emerging environmental issues, examine new technologies, and review routine efforts to ensure they meet current scientific standards. Currently, the WRD is investigating potential stream monitoring methods for climate change; piloting field tablets that allow for all-in-one electronic data entry and uploading on-site, mapping and directions, and web access; and reevaluating river and stream reference sites and their aptitude to assess biological condition.

Water resources in Michigan are everywhere. Monitoring the quality of these resources is vital to ensuring a high quality of life for future generations. Some in the WRD work with ambient water quality, some with point source facilities, and some dedicate efforts to NPS pollution improvements. Whatever the focus, it is important to outline the numerous water quality monitoring activities that occur within the WRD. Table 2 lists all monitoring activities within the WRD.

Table 2. Complete list of monitoring activities with summaries within the MDEQ, WRD. In addition to monitoring shown below, targeted monitoring is conducted (as requested) and surveyed (as approved) through the "targeted monitoring request" process.

Routine Surface Water Monitoring Activities
Water Chemistry Monitoring: • The WCMP, including (1) statewide status and trend water chemistry data collection at 250 probabilistically chosen **river and stream** sites with 50 sites sampled four times annually over a recurrent statewide five-year cycle, and (2) monthly **Great Lakes** sampling (April-November) in Grand Traverse Bay, Saginaw Bay, and Connecting Channels. Note the long-term trend tributary monitoring was discontinued after 2013. All WCMP field sampling is currently contracted out to the Great Lakes Environmental Center (GLEC) with management oversight and other programmatic activities provided by the WRD. • Lake Water Quality Assessment (LWQA): **inland lake** trophic status monitoring was completed in 729 public lakes in cooperation with the USGS from 2001 to 2010. • Landsat satellite imagery for the periods of 2003-2005 and 2007-2008 was performed along with the LWQA and the Cooperative Lakes Monitoring Program (CLMP) water clarity data to predict the trophic state of inland lakes greater than 20 acres in size. Satellite imagery monitoring was renewed in 2014, again in cooperation with the USGS, through a joint funding agreement. Management oversight is provided by the WRD. • Renewed statewide status monitoring began in 2014 with a pilot project to monitor seven lakes for trophic state index and other habitat measurements (e.g., shoreline development). This work continues full-scale in 2016 with plans to establish this project into the WRD routine monitoring. • TMDL implementation monitoring is performed biennially in four southern Michigan TMDL **inland lakes** by WRD biologists. • The MDEQ is a partner on the Great Lakes Coastal Wetland Monitoring project, which conducts **coastal wetland** monitoring throughout the Great Lakes basin (including Canada). Water chemistry monitoring is part of this effort. Others elements are listed below under Biological Condition Monitoring.
Beach and other Recreational Waters Monitoring (pathogens): • Local health departments collect samples each year to assess bacteria levels at **Great Lakes** and **inland lakes beaches**. Data are used by 1) local health departments to determine whether **beaches** should be closed due to high *E. coli* levels, and 2) the WRD to make WQS determinations; results are posted on the MDEQ's BeachGuard Web site. Management oversight is provided by the WRD. • Site selection for *E. coli* sampling on **rivers and streams** is determined from the Section 303(d) list within the Integrated Report (MDEQ, 2014a) and the targeted monitoring request process. The number of projects varies annually depending on available resources. Monitoring is conducted by either WRD staff or its contractors.
Biological Condition Monitoring: • Statewide and watershed status and trends for water quality are determined using probabilistically chosen **river and stream** sites over a five-year basin cycle period. The initial effort (2006-2010) sampled 1192 sites over 5 years. A reduced effort for the third cycle is planned with 525 probabilistic status and trend sites scheduled from 2016-2020.

- The basin cycle is set up to monitor watersheds two years before their National Pollutant Discharge Elimination System (NPDES) permit review year. Biological condition analysis using Procedure 51 (P-51) for wadeable **rivers and streams** is largely limited to the macroinvertebrate community (procedure is also written for the fish community), while Procedure 22 (P-22) for nonwadeable **rivers** is only written for the macroinvertebrate community.
- The MDEQ is a partner on the Great Lakes Coastal Wetland Monitoring project, an effort that conducts **coastal wetland** monitoring throughout the Great Lakes basin, including Canada, and uses protocols to sample fish, invertebrates, vegetation, amphibians, birds, and water chemistry.

FCMP:

- Statewide fish contaminant trend monitoring is routinely conducted in 21 **inland lakes**, impoundments, and **Great Lakes** locations.
- Edible portion monitoring is performed in **Great Lakes, inland lakes, impoundments, and rivers** in Michigan.
- Caged fish are used to identify potential sources of bioaccumulative contaminants.

AIS Monitoring:

The WRD initiated the development of a comprehensive AIS program in 2010, which includes increased AIS monitoring. Key activities consist of:

- Enhanced AIS monitoring when conducting the USEPA-administered NARS.
- An AIS monitoring component added on to all routine wadeable **stream and river** surveys.
- Pilot snorkeling projects were performed in 2014 and 2016 to investigate methods for **inland lakes**. The results will be used to inform the WRD whether routine snorkeling would benefit the AIS program.
- A planning project was concluded in 2014 with the intent to provide several monitoring scenarios based on varying cost and objectives. Results from this, in conjunction with the snorkeling project, will be used to develop a comprehensive AIS monitoring program.
- The WRD supports enhancements to the Exotic Plant Watch, a component of the CLMP.
- Early detection monitoring was piloted in inland lakes in 2016.

Wildlife Monitoring:

- Plasma and feathers from eaglets: monitoring of contaminant trends in plasma and feathers from eaglets has been supported by the WRD since 1999.
- Herring gull eggs: Contaminant monitoring in herring gull eggs has been supported by the WRD since 2002.

These efforts support water quality status and trend goals for the **Great Lakes** and their **watersheds** within Michigan. The University of Maryland holds the contracts for these activities with management oversight provided by the WRD.

Sediment Monitoring:

The WRD monitors potentially contaminated sediments along with effectiveness of past sediment remediation efforts. Monitoring activities can include the collection and analysis of sediment samples and/or toxicity testing and frequently incorporates sampling before and after the sediment remediation. WRD monitoring and sediment staff, along with external agency staff as appropriate, work together to ensure effective, coordinated monitoring projects.

Hydrologic Studies and Geomorphology:

- **Stream** flow measurements; flood and low flow discharge calculations; and hydrologic analyses are performed by WRD staff.
- Geomorphology studies are project-specific. Pre- and post-channel morphology surveys are conducted to assess the effectiveness of channel restoration activities, such as dam removal, culvert replacements, channel relocation, and channel stability problem identification.
- The Michigan Rapid Assessment Method (MiRAM) is used to assess **wetland** functions and values on an equal scale regardless of ecological type, including wetland size, upland buffers and surrounding land use, hydrology, habitat alteration or development, special wetland communities, vegetation, interspersion, microtopography, and scenic and recreational benefits.
- Flashiness status in Michigan watersheds is conducted on a five-year basis using data from USGS **stream** gages.

• Collaborate with the USGS on the **stream** gaging network design and funding strategy. • Fifty-five of the current 145 full-time USGS **stream** gages in Michigan are supported through WRD funding. The MDEQ, along with other government and private agencies with water resources responsibilities and the public, use these monitoring data, which are displayed in real time online for public safety, floodplain management, dam safety, infrastructure design, water use, fish and wildlife protection, environmental enforcement, trip planning for boating and fishing, point source and NPS control, storm water management, and watershed management programs.
Current Special Projects
• Harmful algal bloom and microcystin monitoring on select **beaches** as well as **inland lakes**. • Comparison of the WRD macroinvertebrate protocol to the USEPA National Rivers and Streams Assessment (NRSA) methods for biological condition assessment in **rivers and streams**. • Review of **wadeable river and stream** reference sites for biological condition assessment in the WRD P-51. • Evaluation of NCCA data collecting on Michigan's **Great Lakes** from 2010 to determine its applicability for designated use determinations. • Review the USEPA Region 5 Regional Monitoring Network (RMN) for **rivers and streams** and determine its use in Michigan for climate change monitoring.
NARS Participation:
The USEPA administers the NARS, which take place in **coastal waters, rivers and streams, inland lakes, and wetlands**. The WRD has been awarded Section 106 Monitoring Initiative grants and has assisted with the NARS, often monitoring additional sites to allow for a state-scale assessment. The ability of the WRD to implement these surveys is decided annually. • FY 2009: The WRD received the grant award for the 2010 NCCA and completed all 117 site visits (107 sites with 10 revisits) with WRD and in-house GLEC staff. • FY 2010: The WRD had one staff specialist on the 2011 NWCA team for the 14 sites in Michigan. • FY 2011: The WRD received the grant award for the 2012 National Lakes Assessment (NLA). WRD and in-house GLEC staff completed all 38 sites plus additional state-level sites along with a state-level summary of these data. • FY 2012-2013: The WRD received the grant award for the 2013-2014 NRSA. The WRD and in-house GLEC staff completed the monitoring for the 47 Michigan sites. The additional three sites needed for a state-scale assessment were not added due to federal budget cuts. • FY 2014: The GLEC performed the majority of the monitoring for the 2015 NCCA; WRD staff assisted when possible. • FY 2015: NWCA monitoring in 2016, including a state intensification. • FY 2016: The WRD will monitor the national sites that fall in Michigan for the NLA in 2017 and increase the effort to allow for a state scale analysis. The GLEC will perform approximately 50 percent of the work load for the entire NLA effort.
Monitoring Grants – Administered by WRD staff
Pass-through Grants: WRD project administrators are selected to manage pass-through grants based on watershed and topic expertise. Staff provides technical assistance during work plan and Quality Assurance Project Plan (QAPP) development to ensure the study design, collection and analytical methods, and data analysis meet project objectives. Staff also reviews all financial documents until grants are closed. • **Inland Beach** Grants: $200,000 is available every other year using CMI-CWF monies for these two-year grants. The latest and likely last request for proposal uses FY 2017 CMI-CWFs. • **Great Lakes Beach** grants: Since the Federal Beaches Environmental Assessment and Coastal Health Act (BEACH Act) was initiated in 2003, the MDEQ has allocated $3,291,494 in grant awards for **Great Lakes beaches**. In 2016, the MDEQ awarded 24 grants that totaled $157,107 in federal BEACH Act funds. Funds also supported rapid testing (quantitative polymerase chain reaction [QPCR] method) at **Great Lakes beaches**.

- Local Water Quality Monitoring Grants (**non-beach waters**): This grant opportunity is not currently available. From the beginning of CMI-CWF through 2015, these grants were typically awarded each year to local governments, universities, and nonprofit organizations for local water quality monitoring activities. The typical Request for Proposal was $250,000 and was distributed among five to seven grantees. It is the hope of the WRD that similar grant opportunities will be available in the future with new funding resources.
- NPS grants with monitoring: Some NPS grants have monitoring tasks.

Volunteer Monitoring:

The MDEQ volunteer monitoring program, Michigan Clean Water Corps (MiCorps), has both an **inland lake** and **river and stream** component.

- CLMP volunteers monitor transparency, dissolved oxygen, trophic state, and aquatic vegetation; the CLMP is the second oldest volunteer program in the nation with over 220 member groups.
- The Volunteer Stream Monitoring Program has provided over 44 full grants, 24 start-up grants for benthic macroinvertebrate monitoring, and 3 road/stream crossing grants since 2005. A new parameter, stream flow was piloted in 2016.

MiCorps is currently contracted out to the Great Lakes Commission with management oversight provided by the WRD.

Monitoring Support for Water Resources Programs

TMDL Development Monitoring:

- Any data collected as part of TMDL development for an **inland lake, river and stream, or beach** is implemented through special studies, which can be completed by WRD biologists and engineers during biological condition surveys or completed as a separate task by WRD staff or through the GLEC contract.

TMDL Implementation Monitoring:

- TMDL implementation monitoring is performed, as resources allow, after implementation activities have been conducted. Four inland lakes with nutrient TMDLs are monitored routinely. Other water bodies are monitored as requested by NPS staff to document success stories and through the targeted monitoring request process.

Point Source Support Monitoring:

- NPDES-related ambient monitoring: biological condition monitoring typically occurs in a **watershed** two years prior to its NPDES permit reissuance cycle to ensure monitoring data are considered during permit reviews. Staff in the Permits Section and District Offices of WRD requests sampling locations and parameters (water, sediment, macroinvertebrate/fish community, fish contaminant, etc.) based on facility concerns resulting from compliance sampling inspection data, daily monitoring report data, or housekeeping issues. These locations are submitted as a targeted monitoring request and are typically executed by WRD biologists during biological condition surveys.
- Storm Sewer Overflows (SSO)/Combined Sewer Overflows (CSO) Monitoring: During the five-year rotating watershed surveys, WRD biologists look for evidence of sewage discharge during biological condition surveys and refer findings to district staff for follow-up action.

NPS Support Monitoring:

- The WRD completed a NPS Environmental Monitoring Strategy in September 2004 detailing how monitoring supports NPS efforts (MDEQ, 2004). Specifically, it describes how NPS monitoring priorities are set; how monitoring is used to track improvements in water quality following implementation of NPS controls; and how monitoring results are communicated and used in program decisions. The NPS Strategy divides NPS monitoring into four broad categories, including statewide trend monitoring, problem identification monitoring, TMDL development and effectiveness monitoring, and NPS control effectiveness monitoring. Monitoring is carried out by WRD staff, GLEC staff, and/or NPS grantees.

Perennial Streams Monitoring:

- A perennial **streams** determination procedure was developed by WRD biologists in 2014 to assist Water Use Program staff in the WRD. Perennial **stream** determination requests are made, if possible, during the targeted monitoring request process and WRD biologists perform these evaluations as needed.

Enforcement: • The WRD conducts special studies to support water quality enforcement actions. These studies may include water, sediment, biological, and/or toxicity sampling, depending on the specific issue. Monitoring activities to support enforcement actions are implemented as needed, and are always developed with input from Enforcement and Compliance staff.
AOC Monitoring: The AOC program is located within the MDEQ's Office of the Great Lakes. Staff in the AOC program work with WRD staff for monitoring as needed. Currently, there are 12 AOCs in Michigan, mostly at the mouths of major rivers (two AOCs were delisted in 2014). Therefore, AOC efforts represent **rivers** and **Great Lakes** monitoring efforts.
Lakewide Action and Management Plan (LAMP) Monitoring: The LAMP program, which focuses on open waters of the **Great Lakes**, is located within the MDEQ's Office of the Great Lakes. Staff in the LAMP program work with WRD staff as needed.
Outside Agency, Nonprofit Groups, and the General Public: The targeted monitoring process allows the WRD to receive requests from anyone in Michigan who has a water quality concern.
Drinking Water Monitoring: There are over 70 drinking water intakes in Michigan with the majority located in the **Great Lakes** and **Connecting Channels**. The 2012 Integrated Report was the first time the WRD used raw water intake chloride data to assess WQS attainment from a limited number of water treatment facilities. The WRD updated the Integrated Report assessment methodology to include the comparison of ambient water data to drinking water Maximum Contaminant Levels where data are available; this comparison is used as a screening process to identify when more comprehensive monitoring and assessment may be useful.

Monitoring Design and Objectives

Monitoring Design

Designs for monitoring activities are selected to ensure that management and programmatic needs are effectively addressed. Each monitoring activity is reviewed at appropriate intervals to determine whether the resulting data are achieving agency objectives and to evaluate whether the study design can be improved. In general, WRD monitoring activities fall under one of two types of site-selection design and across a few different project-scale designs:

Site-Selection Design:
- Targeted
- Probabilistic

Project-Scale Designs:
- Basin Cycle
- Statewide
- Special Studies

Site-Selection Design

Depending on the monitoring objective, site selection is either targeted – selected specifically to answer a question about a location/area – or probabilistic – selected randomly to answer a question about a larger area (e.g., watershed, statewide). Within a monitoring activity, both site-selection criteria can be used.

Targeted Monitoring

Targeted monitoring activities support various water quality programs through addressing specific questions and/or issues. Targeted monitoring selection is carried out through our targeted monitoring request process, which has been significantly expanded since the 2005 Monitoring Strategy Update (MDEQ, 2005a). This is the process for anyone who has a monitoring request, including MDEQ staff, other government agencies, non-profit groups, and any stakeholder. By evaluating requests in this manner, monitoring staff in the WRD better communicate with staff in other programs and support the diverse water quality management activities both within and outside of the WRD.

The targeted monitoring process is initiated each October (the beginning of the fiscal year) by updating the web page and sending out a press release and e-mail notices to announce the WRD is accepting requests. While basin year is the main focus, outside-basin year requests are also reviewed. This process gives the WRD a precise estimate of the level-of-effort that will need to be invested each year to meet monitoring goals and affords management and staff an opportunity to discuss any changes, additions, alterations, or deletions of program elements that may be needed.

A targeted monitoring database was created in 2013. It houses all internal and external requests, which are sorted by WRD district boundaries and reviewed in meetings with district staff, WRD watershed biologists, Permit Unit biologists, and water quality/topic specialists. Requests are ranked in those meetings as high, medium, or low priority, and final decisions are made by management based on available resources.

Monitoring assignments from the targeted monitoring request process are carried out by WRD biologists and engineers or the current contractor. The work conducted by WRD staff is incorporated into watershed plans, which are written by WRD staff in preparation for biological condition monitoring. These plans include the monitoring objectives, sampling activities, and the staff/funding resources necessary to carry out the plan. The GLEC was awarded a technical services contract (January 1, 2014 through December 31, 2018). Work conducted by the GLEC is completed as separate work assignments with individual work plans and QAPPs as needed.

Probabilistic

A probabilistic design allows the WRD to measure water quality at a desired scale, such as statewide or watershed. The primary benefit of a probabilistic (random) monitoring design is that statistically valid conclusions about water quality can be made by sampling a relatively small number of sites from the target population. The USEPA requires that states incorporate probabilistic study designs into the monitoring of at least one water body type (e.g., rivers and streams, inland lakes).

The WRD uses this design to assess WQS attainment in rivers and streams and is currently evaluating probabilistic sites for a state-scale wetland condition status and trend program that will build from the 2016 NARS NWCA. In addition, the WRD expands other NARS assessments when desirable to allow for a statewide evaluation of water quality in Michigan.

Note that probabilistic sites can be used to evaluate long-term changes. In these instances, sites become known as “fixed” and part of routine monitoring efforts. Examples of these include, 1) the 250 probabilistic sites chosen for the WCMP are sampled repeatedly over a 5-year cycle to determine changes over time, and 2) a subset of the

2006-2011 biological condition surveys (first five-year basin cycle with sites selected probabilistically) for wadeable streams has been designated as trend stations. These have been (and will continue to be) be sampled during future basin cycles. This will allow long-term changes to be evaluated at the state-scale, and some watershed scales, after a minimum period of three complete basin cycles (15 years).

Project-Scale Design

Monitoring plans are framed to address the scale of the project and the amount of available effort.

Basin Cycle

Due to the extent of watersheds in the state (57 major watersheds as defined as the USGS's 8-digit Hydrologic Unit Codes [HUC]), biological condition monitoring is typically conducted using a five-year basin cycle. This basin cycle approach originated for reviewing NPDES permits but was extended to biological condition monitoring to support the NPDES program and balance the workload. Assessment efforts focus on a subset (approximately 20%) of these major watersheds each year, which establishes the five-year rotating watershed cycle shown in Figure 2 and Table 3. Biological condition surveys and some FCMP and wildlife contaminant activities use this basin cycle to divide effort. The Local Water Quality Monitoring grants (non-beach) used this basin cycle as a means to prioritize grants to be awarded. This did not preclude a grant from being awarded outside of the basin cycle; rather, it guided staff to, over time, select proposals from all regions of Michigan.

Statewide

Statewide monitoring, using either a probabilistic or targeted design, is used to answer "big picture" questions. The WRD currently monitors water chemistry status and trends in rivers and streams each year at the statewide level. The NARS studies also use a probabilistic design to determine biological condition at the national/regional level of all water body types, and the WRD increases the NARS sample size in Michigan when desirable, to make state level determinations.

Special Studies

Special studies are proposed as needed and are vetted through the targeted monitoring request process when possible to determine whether they meet division priorities in relations to all monitoring activities. Each project is designed individually to answer specific questions. Examples of these studies include potential success stories of water quality improvements from Best Management Practices (BMP) installation or geomorphology projects.

Specific Objectives

Each WRD monitoring activity in each water body type has its own list of specific and measureable objectives. For example, the first Strategy goal is to *assess the current status and condition of waters of the state and determine whether WQS are being met.* A specific objective within that goal is to measure the total phosphorus concentration in Saginaw Bay and determine whether that meets 15 micrograms per liter (ug/L), the surrogate measurement for the target load of 440 metric tonnes per year (International Joint Commission, 1983). Objectives are listed in Section 2 under each monitoring activity in each water body type.

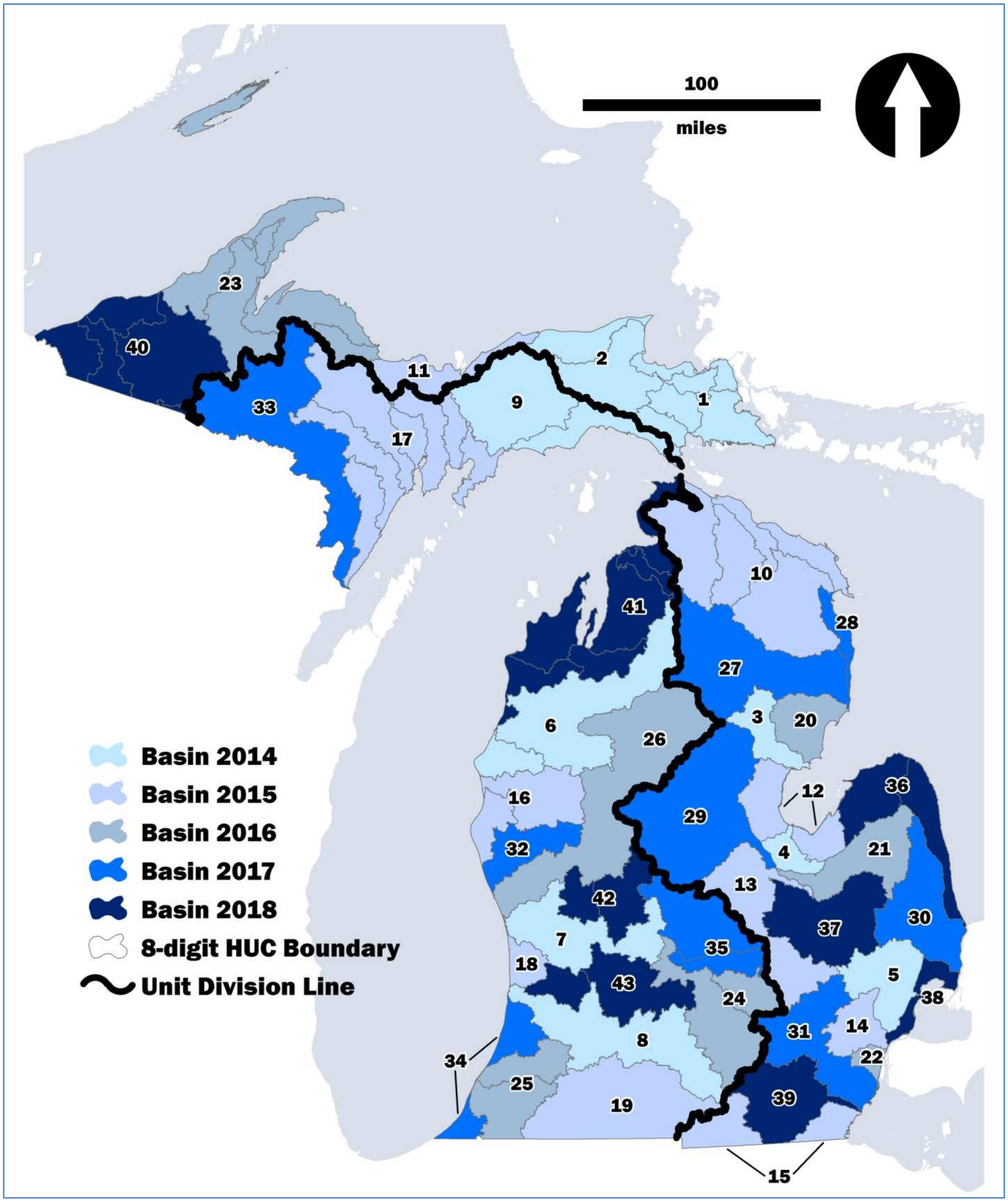


Figure 2. Michigan's watershed groups and basin years as delineated to balance monitoring efforts.

Table 3. List of watershed groups identified for basin year monitoring. Note that several watersheds are true watersheds with an 8-digit Hydrologic Unit Code; however, some watersheds are grouped.

Watershed[1] Number	Watershed Name	8-digit Hydrologic Unit Code
1	Charlotte & Upper St. Mary's	04070001
	Carp; Pine;	04070002
	Munuscong & Lower St. Mary's	04070002
	Pendill's Creek; Waiska	04020203
2	Tahquamenon	04020202
	Two Hearted	04020201
3	Rifle	04080101
4	Saginaw	04080206
5	Clinton	04090003
6	Manistee	04060103
	Big Sable	04060101
7	Lower Grand	04050006
8	Kalamazoo	04050003
9	Manistique	04060106
	Millecoquins	04060107
10	Black	04070005
	Cheboygan	04070004
	Ocqueoc; Swan Creek	04070003
	Thunder Bay	04070006
11	Au Train; Chocolay	04020201
12	Kawkawlin; Pine	04080102
	Wiscoggin	04080103
13	Shiawassee	04080203
14	Rouge	04090004
15	Maumee Tributaries	04100001, -03, -06
16	Pentwater; Pere Marquette	04060101
17	Cedar; Ford	04030109
	Escanaba	04030110
	Fishdam; Sturgeon	04030112
	Rapid; Whitefish	04030111
18	Macatawa	04050002
19	Upper St. Joseph	04050001
20	Au Gres; Tawas	04080101
21	Cass	04080205
22	Detroit	04090004

Watershed[1] Number	Watershed Name	8-digit Hydrologic Unit Code
23	Carp; Salmon Trout	04020105
	Misery; Portage Lake; Tobacc	04020103
	Sturgeon	04020104
24	Upper Grand; Red Cedar	04050004
25	Lower St. Joseph; Paw Paw	04050001
26	Muskegon	04060102
27	Au Sable	04070007
28	Black	04070003
29	Tittabawassee	04080201, -02
30	St. Clair	04090001
31	Huron	04090005, 04100001
32	White	04060101
33	Menominee	04030106, -07, -08
34	Black	04050002
	Galien	04040001
35	Maple	04050005
	Looking Glass	04050004
36	Cherry	04080104
	Pigeon	04080103
37	Flint	04080204
38	Lake St. Clair Shoreline	04090002
39	Raisin	04100002
40	Iron; Presque Isle	04020101
	Upper Wisconsin	07070001
	Montreal	04010302
	Ontonagon	04020102
41	Bear; Pine Boardman; Elk	04060105
	Betsie; Platte	04060104
42	Rogue; Flat	04050006
43	Rabbit	04050003
	Thornapple	04050007

Water Quality Indicators

Current Indicators

Core indicators are the routine physical, chemical, and biological measurements used to assess water quality status and WQS attainment and evaluate temporal trends. These indicators consist of water chemistry values, physical water quality measurements, bacteria counts, biological index scores, and fish and wildlife contaminants levels.

Supplemental indicators are parameters in addition to routine indicators that are used for specific studies. These consider causes of specific water quality questions or impairments and are used to determine the source or extent of impacts such as point sources and NPS, atmospheric deposition, and emerging issues (e.g., microcystin and other algal toxins). Supplemental indicators can also be used to follow up on issues, like determine the effectiveness of a BMP or find causes of impairments.

The core indicators collected by the WRD are consistent with, and go beyond, the list of core indicators recommended in current USEPA guidance (USEPA, 2003). Table 4 lists water quality indicators routinely monitored by the WRD to meet the goals of the Monitoring Strategy. Parameters associated with numeric and narrative WQS have the corresponding designated uses listed (see text box for definition of designated uses).

Designated Uses

All surface waters of the state are designated and protected at a minimum for all of the following designated uses: agriculture, navigation, industrial water supply, warmwater fishery, other indigenous aquatic life and wildlife, partial body contact recreation, and fish consumption (R 323.1100[1][a]-[g] of Michigan's Part 4 Rules, WQS). In addition, all surface waters of the state are designated and protected for total body contact recreation from May 1 to October 1 (R 323.1100[2]). Specific rivers and inland lakes as well as all Great Lakes and specific Great Lakes Connecting Channels are designated and protected for coldwater fisheries (R 323.1100[4]-[7]). Several specific segments or areas of inland waters, Great Lakes, Great Lakes bays, and Connecting Channels are designated and protected as public water supply sources (R 323.1100[8]).

Physical/Chemical:

Physical and chemical indicators include numeric criteria for dissolved oxygen, pH, temperature, and toxics and narrative criteria for nutrients. Water chemistry parameters that have numeric criteria for protection of aquatic life or wildlife are used to determine WQS attainment for the other indigenous aquatic life and wildlife (OIALW) designated use. Water chemistry parameters can also be relevant to other designated uses such as fish consumption. New indicators are evaluated as they become relevant.

Pathogens:

The WRD has an established methodology to evaluate WQS attainment using *E. coli*. Testing currently relies on culture methods that require 18 to 24 hours to produce results.

In 2015, Michigan became the first state to monitor beaches statewide using rapid testing equipment that produces same-day results. The rapid testing equipment uses a method called QPCR, which measures deoxyribonucleic acid (DNA) and produces results in four hours or less. This DNA testing will identify fecal contamination quicker and will help reopen beaches faster when test results show they are safe for swimming. During the transition to QPCR methods, beach monitoring will use results from both culture and QPCR methods to build correlations and comparisons. ***Gap***: There is additional need for pathogen monitoring.

Community health departments do not have sufficient funds (local and grant funds) to monitor all public beaches, and many river and stream miles that likely exceed WQS go undetected considering the percentage of riverine miles that do not meet this designated use.

Note that other pathogens may be monitored. Fecal coliform is measured in wastewater treatment plant effluent and other pathogen indicators have been used in conjunction with *E. coli* to help with source tracking. In addition, the WRD conducts special studies when needed (e.g., water sampling and analysis to determine the presence of *Cryptosporidium* in the River Raisin as it relates to human health and drinking water rules [MDEQ, 2005b]).

Biological Indicators by Water Body Type

Great Lakes

Gap: The WRD does not have any biological indicators used routinely to assess Great Lakes waters. Two potential options are using the MDNR fish collection data from their Great Lakes efforts and indicators from the NCCA.

Rivers and Streams

The WRD has established procedures for evaluating the biological condition of wadeable and nonwadeable rivers and streams. P-51 has two distinct biological community components, one for macroinvertebrates and one for fish, which are used to assess Michigan's wadeable rivers and streams (MDEQ, 1990). P-22 is designed to assess the biological condition using the macroinvertebrate community only in nonwadeable rivers (MDEQ, 2013a). Both procedures use multi-metric indices that result in a single value to rank the water quality at survey locations. Scores below a specific score, or threshold, are considered below WQS.

In 2006, the WRD made two substantial changes to the P-51 biological survey format. First, the site selection process was modified to a probabilistic approach, and second, the number of invertebrates counted at each site was adjusted from an estimate of 100 individuals to a count of 300 (+/- 60) to calculate P-51 scores and assess the OIALW designated use. This process started with an intense effort to ensure a robust sample size that could detect status and trends at the watershed level. In 2016, the data collected during the first two cycles (2006-2010 and 2011-2015) were used to determine whether the sampling effort could be reduced. The decision was made to reduce the number of status sites for the 2016-2020 basin cycle to 525 sites (down from the 1192 sampled during the first cycle) and forego the status analysis at the watershed level (trends at the watershed level will continue to be assessed). There are remaining ***gaps*** where the WRD is evaluating, have plans to evaluate, or at least recognizes regarding biological monitoring in rivers and streams:

- Conclusions in the draft 2008-2009 NRSA led the WRD to request the use of FY 2013 Section 106 Monitoring Initiative Set-Aside dollars to compare the multi-metric scores of P-51 to the NRSA at wadeable locations. This project will determine whether these methods comparably rank biological condition, and if they do not, the work group will evaluate the potential reasons for differences. This project will be complete no later than the expiration date of this grant, which is September 30, 2017.
- The WRD was provided FY 2014 Section 106 Monitoring Initiative Set-Aside dollars to reexamine the reference sites used to calibrate P-51. This project will be complete no later than the expiration date of this grant, which is September 30, 2018.

- Currently, P-51 surveys are often limited to macroinvertebrates only. The WRD recognizes the need to evaluate the appropriate rate that P-51 for fish should be performed in wadeable rivers and streams. Fish community sampling was made feasible in 2014 when the WRD purchased an electrofishing vessel for NRSA monitoring efforts. This vessel is ideal for many water bodies. However, a ***gap*** persists for waters, both streams and inland lakes, that are too large for a stream/barge shocker but without an improved boat launch. Small streams that are largely wadeable can have deep pools that are not conducive for stream/barge shocking. In these situations, a smaller 2-person boat that can be launched manually would be useful. In addition, all backpack fish shocking units for wadeable steams are more when 20 years old. This represents another monitoring ***gap*** that will likely affect the WRD sooner rather than later.
- The WRD recognizes it does not have a method to evaluate whether fish communities meet designated uses in nonwadeable rivers and streams, although data collected by the MDNR is used in some cases.
- It was noted in the 2005 Strategy Update that the WRD would address headwater stream monitoring once the USEPA guidance document on monitoring headwater streams was available. While that guidance document was released in 2006, this remains a monitoring gap today. Note that P-51 is appropriate for small streams. While there is no strict definition regarding what is too small for P-51, the WRD has also not defined what is considered a headwater stream or specifically determined whether P-51 is/is not appropriate for headwater streams as defined by the USEPA.

Inland Lakes

The WRD is using fishery data collected by the MDNR in their status and trend lakes to assess coldwater and warmwater designated uses, as appropriate. The process of assessing WQS with MDNR fish community data was written in 2015. ***Gaps:*** While these data allow the WRD to evaluate fish community data collected at MDNR-Fisheries Division (FD) status and trend inland lakes, there are no plans to use this methodology to measure biological condition at non-FD status and trend inland lakes. In addition, the FD data are limited to determining when inland lakes meet WQS. All other conclusions are listed as “needs further assessment” without a metric to assess further. There are no immediate plans to develop a second biological indicator. The WRD looks to the USEPA for guidance as biological indicators are not widely used at this time in inland lakes.

Wetlands

The WRD relies on several biotic integrity indices for coastal and inland wetland monitoring (including macroinvertebrates, fish, amphibians, birds, and vegetation in coastal wetlands, and macroinvertebrates and vegetation in inland wetlands) and references the NWCA indicators for wetlands including vegetation, soils, hydrology, algae, water quality, and landscape/buffer. The WRD also uses the MiRAM for wetlands monitoring, which includes biological indicators and metrics for: (1) wetland size and distribution; (2) upland buffers and intensity of surrounding land use; (3) hydrology; (4) habitat alteration and habitat structure development; (5) special situations; (6) vegetation, interspersion, and habitat features; and (7) scenic, recreational, and cultural value. More discussion of these indicators and metrics can be found in the 2015 Wetland Monitoring and Assessment Strategy (MDEQ, 2015a).

Fish Tissue

The WRD has an established methodology to evaluate WQS attainment using fish tissue. These data are used by the Michigan Department of Health and Human Services (MDHHS) to develop fish consumption advisories.

Wildlife Contaminants

The WRD has a suite of indicators used to identify water quality trends using eagle plasma/feathers and herring gull egg data. These indicators are used for trend only, not for WQS attainment.

Sediment Chemistry

The WRD does not have the capability to routinely monitor sediment chemistry. The inland lake monitoring effort that collected sediment core data (heavy metals (including total mercury), polycyclic aromatic hydrocarbons (PAHs), and polychlorinated biphenyls (PCBs)) from 2001 to 2010 was possible through a grant to Michigan State University. ***Gap:*** A Great Lakes capable vessel with sediment collection equipment is needed to build capacity for sediment chemistry monitoring. This vessel should be able accommodate large river and inland lake monitoring and be suited to deploy multiple gear types and assess a range of site-specific parameters depending on the targeted monitoring request. Note the WRD is using Section 106 Monitoring Initiative grants to work with a contractor who will retrofit a WRD boat to meet these needs.

Table 4. Routine indicators monitored by the WRD and most commonly associated designated uses. OIALW=other indigenous aquatic life & wildlife; WWF=warmwater fishery; CWF=coldwater fishery; PWS=public water supply; PBC=partial body contact, TBC=total body contact; FC=fish consumption. TSI=trophic state index.

	Indicator	Designated Use	Rivers/ Streams	Inland Lakes	Great Lakes
Physical/ Chemical	Total Phosphorus	OIALW	X	X	X
	Orthophosphorus			X	X
	Nitrogen, Ammonia	WWF;CWF		X	X
	Other Nitrogen species (Nitrate, Nitrate + Nitrite, Nitrite, Kjeldahl Nitrogen)			X	X
	Chlorophyll a (Carlson's TSI)	OIALW		X	X
	Secchi Depth (Carlson's TSI)	OIALW		X	X
	Hardness		X		X
	Cations (Calcium, Magnesium)		X	X	X
	Anion, Chloride	PWS	X	X	X
	Other Anions (Sodium, Potassium, Sulfate)			X	X
	Total Dissolved Solids	PWS		X	X
	Field pH	CWF; WWF; PBC/TBC	X	X	X
	Field Temperature	CWF; WWF	X	X	X
	Field Dissolved Oxygen	CWF; WWF	X	X	X
	Field Conductivity		X	X	X
	Alkalinity			X	X
	Total Organic Carbon				X
	Dissolved Organic Carbon		X		
	Total Suspended Solids	OIALW	X	X	X
	Turbidity	OIALW		X	X
	Total Mercury	OIALW; FC	X		X
	Other Heavy Metals (Total Copper, Chromium, Lead)	OIALW	X		X
	PCBs in water column	OIALW; FC		X	
Pathogens	*E. coli*	PBC/TBC	X	X	X
Biological	Macroinvertebrate Community MMI	OIALW	X		
	Fish Community MMI	CWF; WWF	X		
	Algae, macrophytes, bacteria slimes, fungi	OIALW	X	X	X
Fish Tissue	Hexachlorobenzene		X	X	X
	gamma-BHC (Lindane)		X	X	X
	Aldrin		X	X	X

	Indicator	Designated Use	Rivers/ Streams	Inland Lakes	Great Lakes
	Dieldrin		X	X	X
	Total Dichloro-diphenyltrichloroethane (DDT)	FC[1]	X	X	X
	4,4'-DDE ; 4,4'-DDD; 4,4'-DDT		X	X	X
	2,4'-DDE; 2,4'-DDD; 2,4'-DDT		X	X	X
	PFOS (perfluorooctane sulfonate)		X	X	X
	Heptaclor Epoxide		X	X	X
	Mercury	FC[1]	X	X	X
	Selenium	FC[1]	X	X	X
	Oxychlordane		X	X	X
	Chlordane *(alpha-, gamma-)*	FC[1]	X	X	X
	PAH	FC[1]	X	X	X
	cis-Nonachlor		X	X	X
	Styrene, (octachloro-, hexachloro-, heptachloro-, pentachloro-)		X	X	X
	Heptachlor		X	X	X
	Terphenyl		X	X	X
	Toxaphene	FC[1]	X	X	X
	Mirex		X	X	X
	PBB (FF-1, BP-6)	FC[1]	X	X	X
	Total PCB (congener method)	FC[1]	X	X	X
	Dioxin	FC[1]	X	X	X
Wildlife	Mercury		X	X	X
	Organochlorine contaminants: DDT & its metabolites		X	X	X
	Hexachlorobenzene (HCB)		X	X	X
	alpha-hexachlorocyclohexane (*alpha*-HCH)		X	X	X
	gamma-hexachlorocyclohexane (*gamma*-HCH) Heptachlor		X	X	X
	Heptachlor epoxide		X	X	X
	Chlordane *(alpha-, gamma-)*		X	X	X
	Dieldrin		X	X	X
	Toxaphene		X	X	X
	20 PCB congeners		X	X	X

[1]Fish tissue concentration thresholds developed by the MDHHS.

Quality Assurance

QMP

The WRD recognizes the importance of quality assurance and strives to ensure all monitoring data meet high standards of quality. The MDEQ's Quality Management Plan (QMP) provides the framework to ensure that environmental programs and decisions are supported by data of the type and quality needed and expected for their intended use (MDEQ, 2012). The QMP also ensures that decisions involving the design, construction, and operation of environmental technology are supported by appropriate quality-assured engineering standards and practices. The QMP is updated every five years and was most recently approved by the USEPA on August 6, 2012. Its effective date was February 28, 2013, and will be valid through February 28, 2018.

The QMP is the broad umbrella covering all aspects of quality. It states the MDEQ project manager is responsible for ensuring that program-level and project-level QAPPs follow USEPA specifications (as of this writing these are USEPA QA/R5 and USEPA QA/G-6.). The QMP also references the MDEQ Policy/Procedure Number 09-004, Quality Assurance/Quality Control, which states that all staff, contractors, and grantees involved with the planning, collecting, and analysis of environmental data for the MDEQ must meet established standards for quality assurance and quality control. The other policy guiding data quality is MDEQ Procedure 09-020, which provides the expectations and process for developing program-level and project-level QAPPs. All WRD staff is required to follow these procedures.

QAPP

A QAPP is a document that details the procedures and protocols required for data collection that ensures a project meets its goals and objectives. Under the QMP approval, the MDEQ has the authority to approve its own project-level QAPPs for non-competitive assistance agreements and delegated programs under the performance partnership agreements with the USEPA. These QAPPs are often written by WRD staff but can also be written by contractors and grantees. The WRD has a quality assurance policy and guidance documents to help staff, contractors, and grantees write a sound QAPP. Note that monitoring of Superfund programs require submission to the USEPA, Region 5, for approval as does monitoring for competitive assistance agreements, such as the Great Lakes Restoration Initiative (GLRI).

In addition to the standard operating and section procedures, the WRD and its contractors develop QAPPs for water quality monitoring activities that are federally- and state-funded. The USEPA requires that states develop QAPPs for federally-funded monitoring projects. Likewise, QAPPs must be developed and approved before monitoring using state funds can take place. These documents are required for all monitoring activities.

Field Sampling

The WRD has a *Surface Water Quality Assurance Manual* for water quality monitoring (MDNR 1994). This document contains standard operating procedures for water, sediment, and biological sampling of surface waters and point source discharges used by WRD staff related to water quality monitoring. This process ensures that monitoring data collected to support various objectives and water quality programs are accurate and reliable. ***Gap:*** The WRD recognizes the importance of updating this manual periodically. While some of the procedures included in the manual have been updated, the entire manual has not been reviewed since 1994.

Project Managers and Lead Biologists

Routine monitoring activities within the WRD have project managers who ensure the monitoring goals and objectives are met. There are lead biologists for all watersheds, TMDL lakes, and grant awards. All Section 106 Set-Aside monitoring initiative projects are also led by a project sponsor who oversees work groups to ensure the project stays on task. Project sponsors are generally Unit Chiefs in the WRD.

Internal Audits

The QMP states that audits regarding implementation of the Strategy include, but are not limited to, the review of quality assurance data collected; periodic comparison of biological monitoring results among staff; peer and supervisory review of data analysis and monitoring conclusions; and periodic reviews and updates of monitoring plan elements and designs to ensure monitoring objectives are met.

Laboratory Certifications

MDEQ Environmental Laboratory

The MDEQ Environmental Laboratory is the primary state-run laboratory for analyzing environmental samples for state government facilities in Michigan and is certified by the Laboratory Certification Program, which operates under the authorization of the Michigan Safe Drinking Water Act, 1976 PA 399, as amended (Act 399), and the USEPA. All laboratories testing Michigan drinking water samples for regulatory and compliance monitoring must be certified by this program.

The Laboratory Certification Program certifies laboratories to ensure that proper methods and quality control are used in the testing of drinking water samples. The certification process includes an extensive review of the applicant laboratory QAPP, Standard Operating Procedures, as well as an on-site audit of the facility and analytical data. Areas of certification include bacteriology, wet chemistry, organic chemistry, and inorganic chemistry.

Contract Laboratories

Wisconsin State Laboratory of Hygiene

Some water chemistry samples that cannot be analyzed by the MDEQ Environmental Laboratory are sent to the Wisconsin State Laboratory of Hygiene, which is certified by the Wisconsin Department of Natural Resources and the USEPA on an annual basis.

The WRD has had multiple contracts with this facility, the most recent beginning on September 1, 2012. Currently, the primary use of this laboratory is to analyze trace metal samples (total copper, lead, chromium, nickel, cadmium, and zinc) at concentrations beyond the capabilities of the MDEQ Environmental Laboratory. In addition to these metals, total mercury samples collected in the Great Lakes Connecting Channels and bays for trend analysis are analyzed by this laboratory. This is because the MDEQ Environmental

Laboratory did not have the capability to analyze low-level total mercury when Great Lakes Connecting Channels and bays monitoring was initiated and consistency in sampling staff, methods, and equipment is of the utmost importance when performing trend analysis.

Whitewater and Associates

Whitewater and Associates is currently a subcontractor through the GLEC technical services contract. This company's analytical laboratory is fully certified for drinking water inorganic chemistry and microbiology by the MDEQ and for environmental sample analysis by the Wisconsin Department of Natural Resources.

Data Assessment and Reporting

Assessment Methodology

The WRD uses an established methodology to assess the attainment status of waters against Michigan WQS. This approach ensures all relevant information is consistently used to make water quality assessments for the Integrated Report and for other CWA and state of Michigan regulatory purposes. It includes information regarding how data on Michigan's water bodies are obtained, assessed, and classified during the assessment process. An in-depth description of these considerations is provided in the most recent *Water Quality and Pollution Control in Michigan 2014 Sections 303(d), 305(b), and 314 Integrated Report* (MDEQ, 2014a).

Assessment by Activity

In addition the to the assessment methodology used to determine WQS attainment, other data analysis tools are used depending on the specific objective. Appropriate data analysis is performed for temporal and spatial trend assessment, program effectiveness assessment, and evaluation of emerging issues. Assessment may be limited to data compilation and put into a report. Table 5 lists all monitoring activities and the associated data analysis and assessment. Report format and frequency is also provided. Descriptions of specific assessment methodologies and procedures are listed in Section 2 under each monitoring activity in each water body type.

Reporting

The WRD (sometimes via contractors and grantees) produces reports that summarize the results of all water quality monitoring activities, all of which are available to the general public either through the MDEQ Web site or upon request. Many of these reports include appendices that contain the raw data.

All reports produced by the WRD and its contractors require the completion of a report distribution form before being finalized. The distribution form ensures copies are sent to all interested stakeholders, potentially including, but not limited to, NPDES program staff, NPS staff, WRD district staff, MDNR-FD, and appropriate federal and local agencies.

The reporting process for monitoring activities varies. The WRD recognizes the need for all monitoring reports to be made available. A Web site team comprised of Surface Water Assessment Section (SWAS) staff was formed in 2012. This group has made several improvements to the Web site and has recommended making all reports available online. Table 5 lists all monitoring activities and the associated data analysis and assessment.

Watershed reports often focus on biological community assessments. If warranted by a targeted monitoring request, water and sediment grab samples may be included. Currently, reports also include a specific section describing NPS issues, which was a recommendation in the 2004 *NPS Environmental Monitoring Strategy* (MDEQ, 2004). This is one example of WRD efforts to make sure monitoring results are used by programs that benefit from monitoring. However, data from other sources, such as the MDNR and USGS, may or may not be incorporated. Likewise, data collected by the WRD, including water chemistry fixed station, fish contaminants, wildlife contaminants, inland lake sediment cores, and data collected in past surveys or through WRD grants are often not referenced in the reports. To address the feasibility of incorporating all available data in one document, the WRD developed a comprehensive pilot report on the Menominee watershed in 2015. This pilot report and other recommendations are being evaluated to determine whether this writing philosophy should be incorporated into all watershed reports.

Data Management

A data management system should contain all relevant information (raw data, metadata, and quality assurance information), allow for relatively easy queries and retrieval, and be readily accessible to all data users, including the general public. The majority of WRD water quality monitoring data are stored electronically in at least one of these locations:

- USEPA STORET (**sto**rage and **ret**rieval) data warehouse; the WRD uses the Water Quality Exchange (WQX) framework to submit data to the STORET warehouse
- MDEQ and MDNR Michigan Surface Water Information Management System (MiSWIMS, see text box)
- Microsoft Access databases developed by WRD staff

Much of the data stored in internal Access databases are available to the public via the MDEQ Web site (e.g., FCMP, BeachGuard). However, some data are not yet publicly available except by specific request. The data management status of the various monitoring program components is described below in more detail. Note that location information, primarily latitude/longitude, is now routinely collected by the WRD, contractors, and grantees. This information is included in the various data management systems to facilitate the use of Geographic Information System (GIS) technology for data analysis and map production. Other metadata also are included in the databases.

> Michigan Surface Water Information Management System
> Department of Environmental Quality & Department of Natural Resources
>
> MiSWIMS is an interactive map-based system that allows users to view information about Michigan's surface water. It was developed through a cooperative effort by the Michigan Department of Shared Solutions, MDEQ, and MDNR. Users are able to view and download data collected by the DEQ and DNR from surface water monitoring sites located throughout Michigan.

Available Online

Water Chemistry – data in MiSWIMS and STORET

The water chemistry data management goal is to have all data that are collected by WRD staff and contractors uploaded to the WQX within one year of sampling. This includes all WCMP data (river and stream probabilistic station data and Connecting Channels/bays targeted station data); grab samples collected during biological condition surveys and special studies; and intensive monitoring conducted to support specific program needs. For data generated by other laboratories, WRD project managers are responsible for providing the data as they become available to the data management coordinator for entry into the WQX and/or WRD databases. It is sometimes difficult to meet the one-year objective for water chemistry data availability with the time needed for quality assurance by the laboratory, followed by the quality assurance performed by WRD staff. The WRD staff is working diligently to improve the time frame these data are available electronically.

All water chemistry data generated as part of the LWQA at the 729 public access lakes is stored in the USGS National Water Information System database.

All WCMP data are also stored in an internal Access database, which is used by WRD staff to quality assure and create tables and figures used in reports. This database is not available to the general public. However, the public can retrieve the data through STORET, MiSWIMS, or by a specific information request to WRD staff.

Beach Monitoring – data in BeachGuard and STORET
The WRD has developed the beach monitoring database BeachGuard, which is used to store all beach monitoring data collected by county health departments (primarily) throughout Michigan. The data, which are entered directly into the database by county health department staff, include *E. coli* levels at monitored beaches as well as information on beach closings. This database is readily available to the public on the MDEQ Web site as a direct link and through MiSWIMS. A Web app is also available that broadcasts information about beach advisories in the Great Lakes region. Visit myBeachCast for instructions.

As a requirement of receiving federal BEACH Act funds, the state must submit beach closing information to the USEPA for entry into the federal PRAWN database. In addition, *E. coli* concentration data are sent to the USEPA with a STORET number for entry into the Central Data Exchange, which are then entered into the WQX.

Fish Contaminant – data on the MDEQ Web site
The WRD has developed an Access database to store all of the fish contaminant data. This database is available on the MDEQ Web site as a direct link and through MiSWIMS, making the fish contaminant data readily available to any interested party. It allows users to query the data by a number of criteria, including location, date, or contaminant. The database also is used by WRD staff to create the tables and figures found in the annual FCMP Report. There are plans to enter the FCMP data into the WQX as resources allow.

Sediment Collected During Biological Condition Assessments – Data in STORET
The WRD makes every attempt to enter sediment chemistry data collected during watershed surveys into the WQX within one year of sampling. Historical sediment data that are currently available electronically are ready to be uploaded into the WQX (currently, data have been uploaded into a state version of the WQX); historical sediment data not available electronically will be entered as resources and priorities allow.

NPS Monitoring Grant – Data in STORET
Recipients of NPS pass-through grants are required to provide the majority of environmental monitoring data in an Excel spreadsheet using a template provided by WRD staff. At the close of each grant, WRD staff enters the data into WQX. Note there are data that continue to not be included into the WQX. Examples include, but are not necessarily limited to, projects that use “sniffer dogs” to identify *E. coli* sources, watershed inventories, and Bank Erosion Hazard Index (BEHI) monitoring.

Volunteer Monitoring – on MiCorps Web site
The MiCorps is a network of volunteer monitoring programs in Michigan. It was created through Michigan Executive Order #2003-15 to assist the MDEQ in collecting and sharing water quality data for use in water resources management and protection programs. The lake and stream data generated through the MiCorps are available to the public on the MiCorps Data Exchange

Network. The MiCorps Web site was redesigned in September 2015 to be more user-friendly and utilize new tools and technology to improve communication and data sharing (e.g., optimized for viewing on multiple devices).

Available by Request

Great strides have been made since the previous update to make our data accessible to the public. However, gaps persist as the WRD continues to work on public access for the following data:

Non-Beach Pathogen Monitoring – data to be available in STORET

The non-beach pathogen (primarily *E. coli*) data collected by the WRD and its contractors are not entered into the WQX or any other database, although they are entered into an Excel spreadsheet and are available upon request from the WRD.

Reports Database – reports to be available on the MDEQ Web site

The WRD maintains a water quality monitoring reports database in Microsoft Access, which is available to WRD staff. Reports can be searched by water body name, county, hydrological unit code, or author. This database is not available to the public, although the WRD can provide information upon request. The WRD would like to make these reports available to the public in the future, but no specific timeline has been established.

Sediment Collected for Remedial Investigations – data to be available in STORET

Historically, the sediment contaminant data collected and analyzed by contractors as part of remedial investigations and post-remediation monitoring were not entered into the STORET database or any internal databases. The WRD recognizes these data, along with all data collected, should be available to the public and works to complete this task as time allows.

Inland Lake Field Generated Data – data storage location undetermined

Effort is underway to develop an inland lake database to store all water quality data, including field-generated data collected during lake monitoring efforts (e.g., Secchi depth readings, temperature/dissolved oxygen profiles, habitat and aquatic macrophyte information). It is undetermined whether these data will be readily available to the public or will be available upon request.

Inland lake sediment trend data – data to be available in STORET

The inland lake sediment trend data collected by Michigan State University investigators currently are not entered into the WQX or any other database, although they are entered into an Excel spreadsheet and are available upon request from the WRD.

Biological community data – data to be available in STORET

The biological community (fish, benthic macroinvertebrates) and physical habitat data collected during the watershed surveys or special studies are stored in an Access database maintained by the WRD. Staff has access to the database to generate biological survey and habitat data tables. The database is not directly accessible to the public, but the biological and habitat data can be provided upon request. The WRD is in the process of entering the biological community and physical habitat data (back to 1990) into the WQX.

Local Water Quality Monitoring Grants

The WRD has awarded a number of grants since 2001 to local organizations for water quality monitoring projects. The data produced from these projects are now provided to the WRD electronically; however, the data have not been entered into the WQX. These monitoring grant data will be entered as resources and priorities allow.

Wildlife Database

The bald eagle contaminant and productivity data are entered into a database developed and maintained by the University of Maryland. Data are available upon request, but the database is not accessible to the public. Contaminant data collected on herring gull eggs are stored in spreadsheets and provided in each report. Electronic versions of the data are available upon request.

USEPA’s Assessment Database

The WRD used the USEPA’s Assessment Database for the 2016 Integrated Report. Expectations are that future Integrated Report cycles will use USEPA’s new Assessment and Total Maximum Daily Load Tracking and Implementation System (ATTAINS) database.

Table 5. Monitoring activities performed by WRD staff and summary of data assessment, reporting, and storage. Unless noted, online documents are located under www.michigan.gov/deq. Follow the menu to Water, Lakes and Streams, then Water Quality Monitoring.

Water Chemistry Monitoring:	Report Storage Location
WCMP: trend data analyzed using Seasonal Kendall analysis or regression. Means and medians calculated at all locations. Probabilistic and fixed station comparisons made between Ecoregions using nonparametric statistics (e.g., Mann-Whitney).	Reports Database and Online. Follow *Assessment of Michigan Waters,* scroll to *Monitoring Elements* Water Chemistry.
Trophic-Status: analysis of 729 lakes sampled 2000-2010. Carlson's Trophic State Index; vertical-profile measurements; nutrient measurements at discrete depths; Secchi disk transparency; spring and summer chlorophyll *a* measurements; major ions and other chemical indicators measured in spring at mid-depth; color measurement during the summer from near-surface samples. Summary statistics comparisons performed. Results compared to the CLMP, NLA, and remote sensing data.	Reports Database and Online. Follow *Assessment of Michigan Waters*, scroll to *Monitoring Elements* Inland Lakes Monitoring.
TMDL: generally written within one year of data collection. Specific analyses can be found in each document.	Reports Database and Online. Follow *Assessment of Michigan Waters,* scroll to *Information,* EPA Approved TMDLs.
Bacteria Monitoring:	
Beach Grants: monitoring, notification, sanitary survey, and location data are reported to BeachGuard.	Online: BeachGuard and MyBeachCast for mobile phones.
Annual Beach Monitoring Summary Reports.	Reports Database and Online: Beach Water Monitoring.
WCMP: GIS analysis of *E. coli* data collected at river and stream probabilistic sites to determine scope of problem statewide.	Reports database.
TMDL: A statewide TMDL for *E. coli* is in progress. Storage location represents TMDLs written prior to the statewide TMDL concept.	Reports Database and Online. Follow *Assessment of Michigan Waters,* scroll to *Information,* EPA Approved TMDLs.
FCMP:	
Whole fish temporal trend sampling has been conducted since 1990. Trends are evaluated for each sampling site/species combination using multiple regression techniques. Trend summaries were included in a comprehensive annual FCMP report until 2009 but are separate after 2014 and will be completed every three to five years as new data are available.	Reports Database
Edible portion (fish fillets or other edible portions) of two fish species from an average of 40 water bodies are sampled annually. Data are used by the MDEQ to determine the status of the fish consumption designated use, and by the MDHHS to determine the need for fish consumption advisories. Edible portion reports are written annually.	Reports Database
Caged fish studies are conducted almost exclusively on rivers. Caged fish studies have been conducted at least once on all major Great Lakes tributaries and have been conducted on an as needed basis on several watersheds throughout the state. Caged fish were included in comprehensive annual fish contaminant reports until 2009 and are now written as individual reports as projects are completed.	Reports Database

Biological Condition Monitoring:	
Statewide status and trends: the first statewide status report was written in June 2015. Status is calculated using regression. Trends cannot be calculated until the third basin cycle is complete (2020). Reports will be written every five years after the completion of each basin cycle.	Reports Database
Watershed reports (includes watershed probabilistic and targeted sites): P-51 and P-22 scores are calculated for each survey location. Data are summarized into reports and written one year after field work completion.	Reports Database
AIS Monitoring:	
Pilot inland lake monitoring project to investigate AIS survey methods. AIS are recorded as present or absent. If an AIS is present, approximate density is noted.	Reports Database. Data will also be entered into the publicly available Midwest Invasive Species Information Network at misin.msu.edu.
Routine surveys of wadeable streams and rivers using P-51. AIS are recorded as present/absent. If an AIS is present, approximate density is noted.	Midwest Invasive Species Information Network.
Enhanced AIS monitoring for the NARS. AIS are recorded as present or absent. If an AIS is present, approximate density is noted.	Reports Database and Midwest Invasive Species Information Network.
Wildlife Monitoring:	
Eaglet feathers and plasma: annual reports for spatial analysis with five-year temporal trend reports.	Reports Database and Online. Follow *Assessment of Michigan Waters,* scroll to *Monitoring Elements* Wildlife Contaminants.
Herring gull eggs: periodic reports showing spatial and temporal trends.	Reports Database and Online. Follow *Assessment of Michigan Waters,* scroll to *Monitoring Elements* Wildlife Contaminants.
Sediment Chemistry	
Sediment samples in several inland lakes were analyzed for total mercury, trace metals (cadmium, chromium, copper, lead, nickel, zinc), total PCBs, and organochlorine pesticides such as DDT. Inland lake trend data were summarized in annual trend reports.	Reports Database and Online. Follow *Assessment of Michigan Waters,* scroll to *Monitoring Elements* Sediment Chemistry.
Hydrologic Studies and Geomorphology	
Hydrologic studies are project-specific.	Online. Follow *Assessment of Michigan Waters*, scroll to *Monitoring Elements*, Hydrologic Data Collection and Analysis
The flashiness status of Michigan watersheds is calculated every five years to determine whether stream flashiness is increasing, decreasing, or staying the same. The Richards-Baker Flashiness Index is used with data from USGS gaging stations to quantify the frequency and rapidity of short-term changes in stream flow.	Online. Follow Assessment of Michigan Waters, scroll to Hydrologic Data Collection and Analysis, then NPS Hydrologic Analysis.
Geomorphology studies are designed by project-specific needs and can include cross-section measurements, longitudinal profiles, pebble counts, and/or BEHI.	Reports Database.

Pass-through Grant Monitoring:	
Reports are due at the end of grant project, which is typically a two-year contract.	Reports are available upon request.
Volunteer Monitoring:	
CLMP. New in 2015: contractor writes up annual individual lake reports and separate statewide summary report.	All reports are available on the MiCorps Web site
Volunteer Stream Monitoring Program. Individual reports are written for each stream group.	Reports available upon request.
NARS:	
State-scale reports: The NLA report was written using USEPA statistical methods; future state-scale NARS reports will be handled similarly.	Reports Database.
NPS Monitoring:	
Assessment is project-dependent and can be performed by WRD, GLEC, or NPS staff, or NPS grantees. "Success stories" are due to the USEPA each August 1; large projects are summarized into staff reports (e.g., stamp sand monitoring project). *Note that NPS reporting is described in more detail in the WRD's Nonpoint Source Environmental Monitoring Strategy (MDEQ, 2004).*	Success stories and large projects are entered into the Reports Database and available online. Follow Water to Lakes and Streams. Click on Surface Water, then Nonpoint Source Pollution. NPS program success stories are located under the Information/Education heading.

Programmatic Evaluation

Metrics

The WRD uses a metric approach to track and report on progress. These metrics are organized into four categories: Environmental Stewardship, Internal Business Processes, Financial, and Learning and Growth. The metrics that reflect our monitoring efforts are shown under the Environmental Stewardship category. Information provided in our metrics includes the metric, why it matters, how often it is measured, the goal/target, and how well the WRD is doing in reaching these goals.

Measures of Success

The mission of the WRD is to make Michigan's waters safe and clean for recreating, fishing, drinking, and healthy aquatic ecosystems. The five major goals of this mission align directly with Michigan's WQS and designated uses. These goals are: (1) Enhance Recreational Waters; (2) Ensure Consumable Fish; (3) Protect and Restore Aquatic Ecosystems; (4) Ensure Safe Drinking Water; and (5) Protect Public Safety. For each major goal, measurable outcomes, called our Measures of Success, are identified.

The WRD uses "Measures of Success," last updated June 13, 2013, to define the expected outcomes for many of the issues facing our programs and monitoring activities. Outcomes will evolve as input from other agency staff and stakeholders are provided. The concept of "Measures of Success" started with the MDEQ's former Environmental Advisory Council in its December 16, 2010, report, "Following the Roadmap: Next Steps in Implementing Outcome-Based Environmental Management." The report suggested that relevant outcomes be established for MDEQ programs and monitoring activities and provided specific recommendations for additional outcomes in areas related to water resources protection, restoration, and management.

Measures of success relevant to the Strategy are shown in Section 2 of this report within corresponding monitoring activities in each water body type.

CMI Spending Plan

Monitoring activities funded through the CMI-CWF are reviewed annually when the monitoring coordinator writes an implementation plan. This funding source cannot be used for staff time, so these projects are largely implemented by contractors and grantees. The implementation plan is reviewed and approved by all layers of management, including the MDEQ Director. Implementation plan development allows WRD staff and management to identify new monitoring needs each year, determine which projects should be modified to better meet program objectives, and to eliminate projects when objectives have already been met or otherwise are no longer necessary.

Auditor General

Monitoring activities are subject to audits by the Michigan Office of the Auditor General. These reviews are extensive and may include inquiries of monitoring objectives, work plans, QAPPs, final reports/work products, data availability, and grant/contract paperwork. The final report for the most recent WRD audit, completed in 2014, had 0 negative findings regarding the CWF and the WRD monitoring program (Michigan Office of the Auditor General, 2014). The audit conclusion was that, “DEQ’s efforts to ensure that the use of CMI funds complies with laws, regulations, and contract requirements were effective.”

Internal Controls Evaluation

The MDEQ conducts this evaluation biennially to determine if reasonable assurances exist to show measures are taken to develop reliable financial reports, ensure records are accurate and reporting is reliable, promote effective and efficient operations, and encourage compliance with applicable policies, procedures, laws, rules, and regulations. The Internal Controls Evaluation is conducted by the programmatic supervisor or a designee, signed off by the corresponding Section Chief, and then reviewed by the Administration Division. The overall Internal Controls Evaluation review and any weaknesses or opportunities for improvement are identified to the Division Chief for appropriate changes in the program (MDEQ, 2012).

USEPA Review

The USEPA suggests that states consider a full, detailed review of their monitoring programs at least once every five years with USEPA input. The WRD and USEPA agree that periodic reviews and Monitoring Strategy updates are necessary and plan to discuss the frequency, timing, and substance of future updates.

General Support and Infrastructure Planning

Staffing

The WRD keeps an updated organization chart available online. All Sections in the WRD have some type of monitoring responsibility. This integrated approach to monitoring resources in Michigan affords personnel in the WRD the maximum knowledge and expertise needed to protect human health and water resources. This approach also makes it difficult to estimate actual effort and dollars spent on monitoring.

While monitoring responsibilities span across WRD Sections, the majority of the monitoring effort and coordination is conducted in the SWAS at a rate equivalent to approximately 19 full-time employees. Staffing levels are relatively consistent to the number shown in the 2005 Strategy Update. However, extensive reorganizations make it difficult to compare full-time employee rates between reports. For example, the 2005 Strategy Update did not include monitoring that fell under Wetlands, Lakes, and Streams programs because those efforts were conducted by a separate division that has since been integrated with the WRD.

The monitoring effort today continues to leave the WRD with gaps that cannot be filled. Gaps are identified throughout this document.

CMI

State funds are largely limited to CMI-CWF dollars, which are used for monitoring grants and contracts. Before CMI-CWF became available to support monitoring activities, funding cuts limited the MDEQ's ability to implement the goals in the 1997 Monitoring Strategy. Since 2002, the State Legislature has appropriated approximately $3 million each year of CMI-CWF dollars specifically for water quality monitoring. Several "wish list" monitoring activities identified in the 1997 Strategy have been implemented solely due to these funds.

A spending and implementation plan is prepared each year summarizing the grants and contracts that will be funded with these dollars. Depending on the number and scope of monitoring projects in a given year, the actual amount encumbered is generally less than the $3 million appropriation. Any unencumbered monies revert back to the CMI bond fund, allowing these funds to support future monitoring projects. Beginning in FY 2016 approximately $5 million of the original $45 million CMI-CWF dollars were unencumbered. These CMI-CWF funds are expected to be nearly, if not completely, expended at the end of FY 2018. The loss of these funds will result in a shortfall of approximately $3 million per year and will dramatically impact the WRD's ability to meet to the goals of this Monitoring Strategy. All elements of the monitoring program will be severely affected, including those notably important to the public such as beach, fish contaminant, and volunteer monitoring.

State General Funds

The General Fund refers to state appropriations, expenditures, and receipt transactions that do not fall under special constitutional or statutory requirements requiring separate accounting. In recent years, the WRD had not received any General Funds until FY 2015 when $500,000 was appropriated to be used toward rapid beach monitoring technology. In FY 2016, the WRD received another $400,000 to be used toward technology to investigate harmful algal blooms. It is undetermined whether these funds will continue in future fiscal years.

Program Partner Grant

Section 106 of the federal CWA provides grant funds to states to assist in administering programs for the prevention, reduction, and elimination of pollution. The WRD works to protect and enhance the state's water quality under the authority of Part 31, Water Resources Protection, of the NREPA, and associated rules. Beginning in 2010, Sections 106 and 319 federal funds were combined into the Program Partner Grant.

In FY 2016, the MDEQ was awarded approximately $11.2 million in the Program Partner Grant. Monitoring is one of many activities that are supported by the Program Partner Grant. These activities include:

- Management and administration
- Permit issuance
- Compliance
- Enforcement
- Monitoring and assessment
- Management of water quality and program data
- Section 401/Rule 97 Certification
- Develop the Integrated Report
- Restore and protect waters impaired or threatened by NPS pollution

BEACH Act Funds

Since 2003, the MDEQ has annually received between $173,054 to $376,668 in BEACH Act funds for monitoring Great Lakes beaches. This funding provides grant awards to county health departments to develop and implement Great Lakes beach monitoring programs and supports a 0.75 full-time employee to the WRD for program management. A total of $173,054 BEACH Act dollars was allocated to the MDEQ for FY 2017. Please note the level of funding currently available to Michigan through the BEACH Act is not sufficient to meet all Great Lakes beach monitoring needs, and it is unknown whether these funds will be available in FY 2018 and beyond.

Federal Section 106 Monitoring Initiative Funds

Beginning in FY 2005, Congress specifically dedicated a portion of the CWA Section 106 annual appropriation as Water Quality Monitoring Strategy Implementation funding. These supplement the base Section 106 grant and have two components: (1) funding for states, tribes, and other eligible entities to participate in statistically-valid surveys of the Nation's waters; and (2) funding for states and other eligible entities to enhance their water monitoring and assessment programs consistent with their monitoring strategies.

This allocation, also referred to as enhancement funding, has approximated $160,000 each year. These funds are "set aside" to fill monitoring gaps identified by agencies. The difficulty with the restrictions on these funds is that, depending on the enhancement project, these new activities or "filled" gaps are often unsustainable. Once an agency fills a gap, there are no funds added to the Program Partner Grant or available from another source to sustain that monitoring activity.

GLRI

The federal budget has included GLRI funds since FY 2010, which target significant problems in the region, including invasive aquatic species, NPS pollution, and contaminated sediment. The USEPA and its federal partners coordinate state, tribal, local, and industry actions to protect, maintain, and restore the chemical, biological, and physical condition of the Great Lakes. The MDEQ has received several GLRI grants that included monitoring for beaches, AOCs, Lake Michigan (Coordinated Science and Monitoring Initiative), sediment remediation, fish contaminants, and wetlands among other things.

Wetland Program Development

Wetland Program Development grants have been an important funding source for development of the wetland monitoring strategy and now the initiation of Level III monitoring (see Wetland Section of this document).

Training

In-house trainings are given by WRD staff, with topics such as grants management, geomorphology, and AIS identification. Funding for staff to attend conferences and outside training is limited. This is unfortunate as conferences and training can provide insight and skills that are new to all WRD staff. These opportunities, often missed due to funding restraints, would allow staff to initiate changes in our processes and increase efficiency, effectiveness, and the quality of our work, along with obtain field, statistical, and data management training.

Staff has access to limited professional development funds provided by the state of Michigan that are funded through union dues. These funds are available at a maximum of $950 each year and are provided on a first come, first serve basis at the beginning of each fiscal year. Training opportunities outside of the MDEQ budget have recently been identified through scholarships. Biologists have attended the biennial National Water Quality Monitoring Council's Conference through scholarships (typically one biologist each conference), which afford statistical training opportunities, including training using the statistical program R. Staff looks forward to future scholarship opportunities and will continue to apply when presented.

Equipment

The primary mechanism for major equipment purchases is currently through the Section 106 Monitoring Initiative Funds and Wetland Program Development Grants. The drawback is these funds can only be used to purchase equipment needed to complete NARS assessments, fill a monitoring gap, or develop a new monitoring element – not to replace or maintain equipment used for routine monitoring.

Note that equipment purchased to carry out a NARS assessment can also fill other monitoring gaps. For example, the purchase of two inflatable boats for the 2012 NLA gave the WRD the ability to conduct the nonwadeable procedure in-house, a survey used to assess the OIALW designated use in large rivers. Prior to 2014, this work was contracted to the GLEC. These funds can also lead to the replacement of worn out equipment in select circumstances, such as the electrofishing boat that was purchased in 2014 when the WRD could not complete the boatable NRSA sites without a new electrofishing boat.

However, equipment maintenance and replacement is a part of environmental monitoring. Utilizing other sources would direct funding away from personnel, which is not desirable. A small annual budget from a combination of relevant funding sources is available to purchase routine field supplies, repair/maintain equipment and boats, and to replace worn equipment such as type III and IV personal floatation devices, safety equipment, chest waders, and rain gear. The WRD does not have a solution to the problem of equipment maintenance and replacement. This is a ***gap*** that is underlying to all WRD monitoring programs.

Currently, the WRD has the following equipment and supply needs:

- Great Lakes vessel/motor/trailer with sediment collection capabilities
- Inland lake sampling boat/motor/trailer
- Motors for boats that range in size from 14-18 feet long to increase capacity of inland lake monitoring activities for new and growing programs
- Small electrofishing vessel for waters without an improved boat launch
- Potential near-term replacement of up to six backpack fish shockers
- Field tablets
- GIS software
- Software for data management
- Electronic data storage space
- Sonde replacement and maintenance

Laboratory

Nearly all laboratory expenses are funded using CMI-CWF. It will likely be difficult to cover analytical needs when these dollars are completely exhausted.

Section 2: Michigan's Surface Water Resources

Grand Traverse Bay, 2010.

Routine Monitoring

Water Chemistry

The Great Lakes water chemistry monitoring objectives are:

1) Determine the current water quality and WQS attainment in the Connecting Channels, Saginaw Bay, and Grand Traverse Bay.
2) Determine water quality spatial and temporal trends in the Connecting Channels, Saginaw Bay, and Grand Traverse Bay.
3) Provide support to the AOC and LAMP programs in the Office of Great Lakes and other agencies.
4) As needed, evaluate emerging contaminants in the Great Lakes
5) Provide data for the WRD Measures of Success.

WCMP

In 1997, there were only 21 long-term water chemistry monitoring sites in Michigan's surface waters, and those sites were limited to the Detroit River and Saginaw Bay. This number of sites represented a reduction of nearly 80% compared to "over 100" monitoring locations that were assessed in the 1980s. The passage of the CMI-CWF in 1997 lead to a broader program that collected water chemistry in all of Michigan's Connecting Channels, Saginaw Bay, Grand Traverse Bay, and major tributaries. This program, the WCMP, began in 1998 and was fully implemented in 2002. Note this program has been almost entirely supported with CMI-CWF dollars since 2002 and will continue to be until this funding expires.

Tributary monitoring is no longer part of the WCMP routine monitoring. After 2013, it was determined the objectives of the tributary portion of the WCMP, which analyzed nutrient loadings to the Great Lakes, had been met. The WRD documented WQS attainment and status and trends from these 27 tributaries for more than 15 years. If new funds become available, the WRD will determine whether to reinstate tributary monitoring, which would likely be developed with new objectives (e.g., concentrate monitoring in areas with specific water quality questions or programmatic concerns).

Parameters sampled include the core indicators shown in Table 4. Table 6 shows the methods and quantification levels associated with each parameter collected as part of the WCMP. Note the low-level heavy metals are analyzed at trace levels for trend analysis.

Two targeted stations are sampled in each Connecting Channel, one near the head and one near the mouth of the St. Clair, Detroit, and St. Marys Rivers (Figures 3-4). Sampling is performed monthly by GLEC at stations from April through November during ice-off conditions.

Table 6. WCMP tributary station water chemistry parameters, analytical methods, and quantification levels. SM = Standard Method; mg/L = milligrams per liter; ug/L = micrograms per liter; ng/L = nanograms per liter; Nephelometric Turbidity Unit (NTU)

Parameter	Analytical Method	Quantification Level	Unit
Alkalinity (as CaCO3)	310.2	20	mg/L
Ammonia	350.1	0.010	mg/L
Carbon, Total Organic	415.1	0.5	mg/L
Phosphorus, Total	365.4	0.005	mg/L
Phosphate, Ortho	365.1	0.003	mg/L
Nitrate	353.2	0.01	mg/L
Nitrate + Nitrite	353.2	0.010	mg/L
Nitrite	353.3	0.002	mg/L
Nitrogen, Kjeldahl	351.2	0.10	mg/L
Hardness	Calculated	5	mg/L CaCO3
Calcium	7140/3111B SM	1	mg/L
Magnesium	7450/242.1	1	mg/L
Potassium	7610/258.1	0.1	mg/L
Sodium	7770/273.1	1	mg/L
Chloride	325.2	1	mg/L
Sulfate	375.2	2	mg/L
Solids, Total Dissolved	Calculated	20	mg/L
Suspended Solids, Total	2540D SM	0.5	mg/L
Turbidity	180.1	1	NTU
Temperature – Field	Field probe		°C
Conductivity – Field	Field probe		umhos/cm
Dissolved Oxygen – Field	Field probe		mg/L
pH – Field	Field probe		pH S.U.
Mercury, Total	1631	0.45	ng/L
Copper, Total	1638[1]	0.1	ug/L
Chromium, Total	1638[1]	0.19	ug/L
Lead, Total	1638[1]	0.014	ug/L

[1]Method is consistent with USEPA Method 1638.

Saginaw Bay is sampled monthly from April through November at seven targeted locations (Figure 5). Surface samples are taken at each site with an additional mid-water column sample taken at one of the surface locations. All parameters are sampled each month, with trace metals, including mercury, only collected at four of the eight sampling locations.

Grand Traverse Bay is sampled at four targeted locations in May, July, and October (Figure 6). Sampling trace metals, including mercury, is limited to the fall sampling event. All other parameters are collected during each sampling event.

Trace low-level metals (including total mercury) are sent to the Wisconsin State Laboratory of Hygiene for analysis. All other water chemistry samples are analyzed by the MDEQ Environmental Laboratory. At this time, the only heavy metal the MDEQ Environmental Laboratory can analyze at the trace low-level required for trend monitoring is total mercury. Unfortunately, this capability was not in place until after this program was launched. The WRD chose to continue the trace low-level mercury analysis at the Wisconsin State Laboratory of Hygiene to minimize potential variability associated with a change in laboratory.

Figure 3. St. Clair River and Detroit River WCMP site locations.

Figure 4. St. Marys River WCMP site locations.

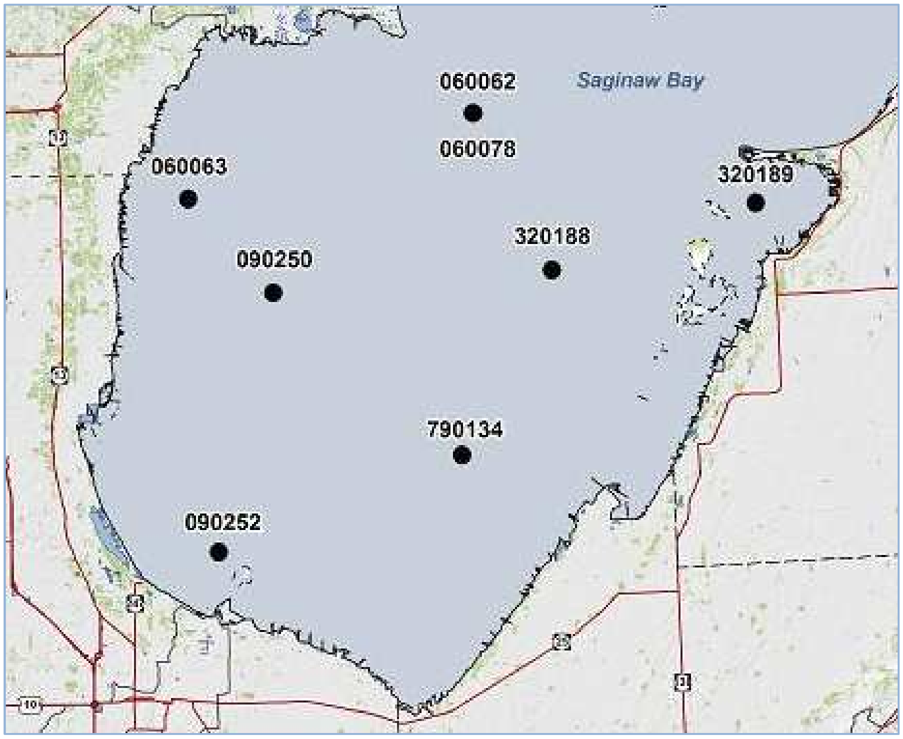


Figure 5. Saginaw Bay WCMP site locations.

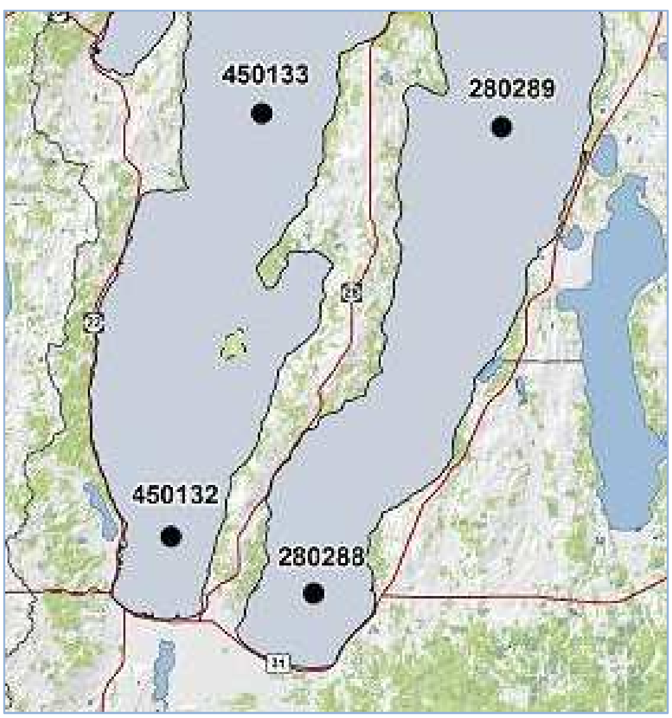


Figure 6. Grand Traverse Bay WCMP site locations.

Data are quality assured and quality controlled by the laboratories. Further quality control is performed by the WRD to ensure dates are correct and that replicates fall within a reasonable percent difference of the sample. Data are stored in an internal Access database and then uploaded to MiSWIMS and the WQX.

Concentration data at all Connecting Channel and bay sites are used to report on water quality status and trends and make WQS attainment determinations, which are incorporated in the Integrated Report. The Connecting Channel data are provided to the USGS, who uses concentration and flow data to develop loading estimates.

Water chemistry data are used by the AOC and LAMP staff in the Office of the Great Lakes, several universities, and other government agencies. The most recent WCMP report includes Connecting Channel, Saginaw Bay, and Grand Traverse Bay data for 1998-2008. This report, along with all previous reports, is available on the WRD Water Chemistry Web page.

The Measures of Success desired outcomes for Saginaw Bay and Grand Traverse Bay are evaluated using WCMP data. These outcomes are: (1) meet the total phosphorus goal in Saginaw Bay of 15 ug/L; and (2) maintain a neutral trend in total phosphorus in Grand Traverse Bay. The current reported outcome is that we are doing "fair" for Saginaw Bay and "excellent" for Grand Traverse Bay.

Beach Monitoring

The beach monitoring objectives in the Great Lakes are:

1) Support county health department monitoring efforts through technical support and grant opportunities using federal funds from the BEACH Act.
2) Collect *E. coli* data to determine WQS attainment at Great Lakes beaches.
3) Create and maintain a statewide database.
4) Provide data for the WRD Measures of Success.

The health officer of a county health department has the authority to determine if a beach should be open or closed. The WRD bacteria monitoring on Michigan's Great Lakes beaches is conducted through grants awarded to county health departments for monitoring *E. coli* levels using federal BEACH Act dollars (inland beaches are monitored using State CMI-CWF funds, which is discussed in the Inland Lake Section) and local funds. County health departments use the results to assess whether the beach water quality is safe for swimming and whether beach closings are necessary. Sampling procedures and allowable *E. coli* levels are defined in the Michigan WQS.

The WRD provided 24 grants totaling $243,353 in 2015 using federal BEACH Act funds to county health departments for monitoring Great Lakes beaches. A total of 617 public beaches have been identified on Michigan's Great Lakes. Of these, a total of 209 beaches (34%) were monitored in 2015 (MDEQ, 2016b). The WRD attempts to fund all counties that submit proposals, though not always at the full level requested. The WRD uses data collected and reported by the local health departments to determine whether PBC and TBC WQS are attained. Whenever a location is found that does not meet the recreation designated use, the WRD continues to monitor the site and develops a TMDL.

The MDEQ developed a centralized statewide database, BeachGuard, which includes beach locations and maps, beach monitoring *E. coli* test results, notification data, and routine sanitary survey data. These data are available electronically to the public via the MDEQ's Web site (https://www.egle.state.mi.us/beach/). The Web site provides the following information about individual beaches:

- Location information (county, water body, and coordinates for latitude and longitude)
- Frequency of testing
- Monitoring history
- Beach closures
- Monitoring efforts
- Search tools
- Options for data export
- Information for beach monitoring procedures and methods

- Additional links to beach monitoring resources
- Contact information for federal, state, and local beach monitoring staff

BeachGuard is also connected to a beach application for mobile phones that was created by the Great Lakes Commission. The beach application is called *MyBeachCast* and retrieves beach locations and their status from BeachGuard. The beach application is available from *(The link provided was broken and has been removed)* and a mobile-enhanced Web site is available on the Great Lakes Information Network *(The link provided was broken and has been removed)* that offers information for Web viewers, iPhones, and other mobile devices.

The Measure of Success desired outcome that pertains to beach health is that 100% of monitored Great Lakes and inland lakes beaches would be safe for swimming. This outcome is measured as the percent of monitored beaches with no closures or advisories due to unacceptable levels of *E. coli* during the recreational season. Percentages increased in 2011 when beaches with known or suspected water quality problems were targeted for intensive monitoring to identify sources of contamination. The WRD continues to work with local communities to identify sources of contamination and implement corrective actions to restore water quality. Much of this work is funded by the GLRI. However, in 2014, the WRD provided funds for real-time beach monitoring equipment for a lab at the Lake St. Clair Metropark Beach, and the WRD FY 2015 budget included $500,000 to provide real-time beach monitoring equipment and technology for ten more communities in Michigan.

Biological Condition

Currently, the WRD does not have an indicator for monitoring biological condition in the Great Lakes.

Fish Contaminants

For environmental, resource, and logistical reasons, fish tissue often is an appropriate measure for bioaccumulative contaminants. Fish tissues are analyzed for PCBs, mercury, and a suite of industrial chemicals and pesticides such as DDT (See Table 4 for complete list of core indicators in fish tissue). Samples may be selected to be analyzed for dioxins and dioxin equivalents; others may be analyzed for emerging contaminants such as perfluorinated compounds, polybrominated diphenyl ethers (PBDE), or selenium.

The objectives for fish contaminant monitoring in the Great Lakes are:

1) Support the MDHHS fish consumption advisories.
2) Determine WQS attainment for the fish consumption designated use.
3) Investigate emerging contaminants as needed.
4) Evaluate remediation efforts and impacts from point sources.
5) Evaluate temporal trends in fish contaminants.
6) Provide data for the WRD Measures of Success.

Edible Portion Monitoring

Fish consumption monitoring is met by sampling the edible portion of key species collected from Michigan waters of each of the Great Lakes and Connecting Channels.

The WRD collects fish from selected locations each year to measure contaminant levels in edible portions (generally the fillet). The expected upcoming number of fish collection sites annually is 20-30, which is similar to past efforts. Fish are processed by WRD staff and sent to the MDHHS laboratory. If the concentration of any contaminant exceeds any MDHHS screening value, a consumption advisory is issued and the affected water body is determined to be in nonattainment of the WQS. The current exception is the mercury in fish tissue criteria for the WRD assessment methodology, which uses the two meals per month MDHHS screening value. This reflects the 0.35 milligrams per kilogram (mg/kg), which is part per million, fish tissue value (minimum of five legal-size top predator fish).

The Measures of Success for fish consumption that relate to human health are:

- Reduce mercury levels in edible portions of Great Lakes, inland lakes, and stream fish to below 0.35 mg/kg by 2020.
- Eliminate PCB contamination – Reduce PCB levels in edible portions of Great Lakes, inland lakes, and river fish to below 0.05 mg/kg by 2025.
- By 2025, achieve an average concentration of 0.53 nanograms per kilogram (ng/kg), which is parts per trillion, dioxin toxic equivalent levels in fish in the Saginaw River and Saginaw Bay (this applies to both human health and trends).

The Measure of Success for mercury concentrations in fish is measured using the 90th percentile of length normalized walleye, northern pike, or largemouth bass fillets from selected sites in the Great Lakes and inland waters. The likelihood this objective will be reached by 2020 is poor. The mercury concentration in these fish appears to be greatly dependent on the mercury from atmospheric deposition, which is primarily due to burning coal to generate electricity. Currently in Michigan, coal fired power plants discharge about 4,000 pounds of mercury per year to the atmosphere, while point source wastewater facilities discharge less than 20 pounds per year to surface waters.

The Measure of Success for PCB concentrations in fish is measured using the 90th percentile of lipid normalized carp fillets (site dependent) from selected sites not impacted by legacy pollution. The likelihood this objective will be reached by 2025 is fair according to data collected in recent years. The PCB ban has been in effect for 30 years. Point source discharges have been controlled, and several sediment remediation activities for PCBs have been completed. The recent decline in the rate of change is a reflection of the ubiquitous nature of PCBs in the environment, its slow degradation rate, and the global transport of PCB once it is released.

The Measure of Success for dioxin contamination is measured by evaluating temporal trends in lipid-adjusted dioxin toxic equivalent concentrations in whole carp from Saginaw Bay. The likelihood this objective will be reached by 2025 is fair considering these achievements: the primary point source discharge of dioxin has been controlled; a large PCB sediment remediation of the Saginaw River was completed that likely removed dioxins as well; and several hot spots of sediment contaminated with dioxin have been removed from the Tittabawassee River.

Whole Fish Trend Monitoring

The WRD has established 22 fixed stations that are sampled every three to five years to measure temporal trends in bioaccumulative contaminants in fish tissues (Figure 7). Ten of the sampling sites are in the Great Lakes or Connecting Channels. This effort analyzes whole fish samples of one to three sentinel species (see Table 4 for the list of indicators).

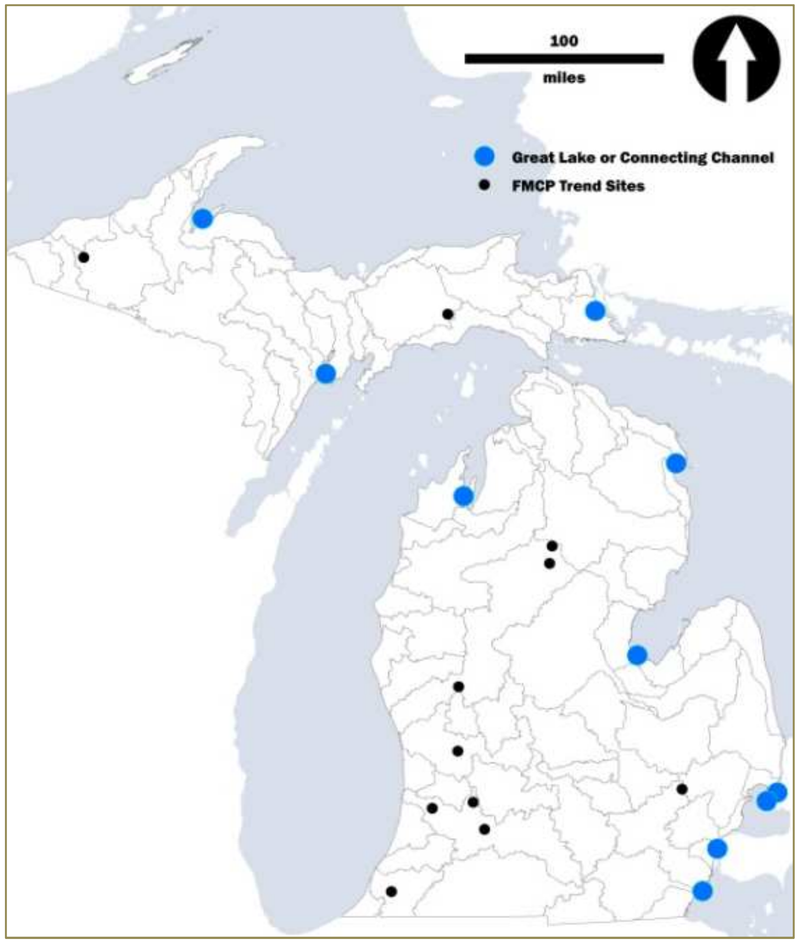


Figure 7. Michigan's 22 fixed trend fish contaminant stations. Locations highlighted in blue are considered the Great Lakes stations.

The Measure of Success regarding the enhancement in quality of the Outstanding International Resource Waters – the Lake Superior Basin – aims to maintain declines in PCBs, DDT, chlordane, and dioxins in whole lake trout from Keweenaw Bay. Lake trout have been collected from Keweenaw Bay every two to three years since 1991. Temporal trends in contaminant concentrations are evaluated using regression techniques. These declines are expected to continue. An additional objective is to begin to show measurable declines in Lake Superior lake trout mercury concentrations by 2020. Currently, there is no detectable downward trend in mercury concentrations in whole lake trout from Lake Superior; however, concentrations are also not increasing as we see in the other Great Lakes.

AIS

The WRD hired an Aquatic Biology Specialist in 2010 focus on AIS issues. Due to the heavy workload, two additional staff were added to this effort. The majority of the work was policy and procedurally related, so monitoring within the WRD was initially limited to "add-on" observations made by SWAS biologists during routine field sampling. In addition, the WRD partnered with Central Michigan University in 2013 to investigate AIS monitoring nationally and determine what attempts were applicable to support planning efforts in Michigan (205j grant awarded by the USEPA). Then in 2014, the WRD partnered with the Nature Conservancy for a Great Lakes-specific interstate project (GLRI project awarded by the United States Fish and Wildlife Service).

In 2015, the WRD hired a second Aquatic Biology Specialist into a limited-term position in the Lakes Erie, Huron, and Superior Unit of the SWAS to create AIS monitoring objectives that address *Michigan's Aquatic Invasive Species State Management Plan 2013 Update* goals, which are: prevent new introductions, limit established populations, early detection, and manage

AIS (MDEQ, 2013b). Monitoring efforts have since increased and include piloting inland lake methods (e.g., snorkeling) for early-detection and designing special projects that follow up on distribution and extent of isolated populations of AIS. This specialist will also evaluate the Measure of Success associated with AIS monitoring in the Great Lakes, which is to reduce the rate of introduction of AIS into the Great Lakes to one species every 30 years by implementing preventive measures.

Wildlife Contaminants

Monitoring the productivity and contaminant levels in fish-eating (piscivorous) wildlife provides valuable information on the health of the Great Lakes ecosystem. Many persistent contaminants occur at biologically relevant concentrations in the environment that are not easily measured in water. In addition, wildlife can serve as a "first alert" for the detection of changes in environmental quality and the potential for adverse effects to occur on human health. Monitoring contaminant levels in wildlife also provides useful information on changes in contaminant concentrations over time, which helps the MDEQ determine whether programs have resulted in environmental improvements. Wildlife monitoring also helps the MDEQ locate "hotspots" of contamination and assess whether wildlife is being adversely impacted.

Wildlife contaminant monitoring currently consists of two components, bald eagle nestling plasma/feathers and herring gull eggs, which provide data necessary to achieve the following objectives:

1) Determine contaminant levels in piscivorous wildlife using bald eagle and herring gull data.
2) Assist in the identification of waters that may exceed WQS and target additional monitoring activities.
3) Evaluate the overall effectiveness of MDEQ programs in protecting wildlife from toxic contaminants.
4) Support AOC efforts to evaluate Beneficial Use Impairments (BUIs).
5) Determine whether new chemicals are accumulating in wildlife.
6) Provide bald eagle data for the WRD Measures of Success.

Bald Eagle Nestling Plasma/Feathers
Because many persistent contaminants occur at biologically relevant concentrations in the environment but are not easily measured in water, the WRD began monitoring environmentally persistent and toxic contaminants in bald eagles in 1999. The CMI-CWF provided the WRD with the long-term opportunity to collect data to evaluate spatial and temporal trends and compare those data to historical data available in the scientific literature.


Eaglets in nest on Long Lake – photo courtesy of Dr. William Bowerman

Nesting eagles are found along the shorelines and on islands of each of the four Great Lakes surrounding Michigan and across much of Michigan. Currently, active bald eagle breeding areas are well distributed across the Upper Peninsula and northern Lower Peninsula of Michigan; breeding areas continue to increase in southern Michigan to either establish new or reoccupy historical territories.

Since 1999, the MDEQ has funded researchers from various universities (Michigan State University, Clemson University, and the University of Maryland) to measure contaminant levels in bald eagle blood and feathers each year, track year-to-year variability of concentrations, and evaluate contaminant trends. The bald eagle monitoring project design provides monitoring coverage of both the coastal Great Lakes and inland waters (however discussion is limited to the Great Lakes section). Great Lakes associated nests are defined as those nests within 8.0 kilometers of the shorelines of the Great Lakes and along tributaries where anadromous fish are accessible. Eaglets from selected nests have been monitored annually, while others have been sampled according to the MDEQ's five-year rotating basin schedule. Samples are analyzed for PCBs, mercury, DDT, and a few other selected pesticides (See Table 4). Previous bald eagle contaminant data were collected in the late 1980s and early 1990s. Thus, the current effort allows the MDEQ to measure temporal, as well as spatial, trends in contaminant levels.

Three Measures of Success outcomes are evaluated using WRD bald eagle data. These are:

- Reduce the levels of contaminants in the environment so the productivity (i.e., total number of fledged young per occupied nest) and success rate (i.e., percent of nests producing at least one fledged young) of bald eagles are at levels associated with a healthy population.
- Reduce the levels of PCBs and DDE in the environment so they are below levels associated with adverse effects in eaglets.
- Reduce the levels of contaminants in the AOCs that have a "Bird or Animal Deformities or Reproductive Problems" BUI so the average bald eagle productivity is at the level associated with a healthy population.

Herring Gull Eggs
The herring gull projects started in 2002. Herring gull eggs are collected annually at five colonies along the Great Lakes in Michigan. This project complements the herring gull egg monitoring project conducted by the Canadian Wildlife Service. The resulting data are used to assess spatial and temporal trends in bioaccumulative contaminants in the Great Lakes.

This work is conducted by the same researchers who work on the bald eagle project. In addition to the same bioaccumulative contaminants of concern such as mercury, PCBs, and chlorinated pesticides (e.g. DDT) that are tested in bald eagles, herring gull samples are also analyzed for dioxin and furans. Periodic reports are also published for the herring gull project.

Sediment Chemistry

Sediment remediation projects are performed in targeted areas. While these projects are often focused in AOCs to help evaluate progress towards delisting fish consumption and dredging restriction BUIs, other programs may request support. There are no established core indicators for sediment; however, heavy metals (including mercury), PAHs, and PCBs are often collected at a minimum and toxicity testing may also be conducted. Indicators in sediment are specific to the site and pollutant of concern.

The WRD has historically been involved in various sediment remediation projects. Currently, the WRD is the project administrator for a $20 million PCB remediation grant on the Manistique River with the National Oceanic and Atmospheric Administration. This remediation project began in 2014 and will continue into 2017, to be followed-up with post-remedial monitoring. The WRD also currently provides technical support for Rouge River, Detroit River, and River Raisin remediation projects. Support includes the review of remedial and sampling plans and assistance with development of sampling plans.

Gap: The WRD requires a vessel capable of performing sediment remediation projects. At this time, these projects are carried out using a USEPA vessel. To meet this need, the WRD is using Section 106 Monitoring Initiative funds to retrofit a vessel currently in storage. This retrofit will include the addition of equipment for sediment coring and other monitoring efforts (e.g., winch for ponar dredge). This vessel will allow the WRD to fulfill current targeted monitoring requests from internal and external stakeholders in inland lakes, rivers, Great Lakes harbors, and Connecting Channels.

Special Projects

Lake Erie Monitoring

The WRD began conducting water quality monitoring at beaches in the Michigan portion of Lake Erie in 2012 to investigate possible harmful algal blooms and other nutrient-related impacts (e.g., nearshore attached algae, beach/shoreline muck) on designated uses. Seven targeted beaches extending from Luna Pier north to Estral Beach (Figure 8) were sampled roughly every two weeks from June to September each year, for a total of eight to ten visits a year. The monitoring included photos, nutrient and microcystin sampling (grab sample from approximately 0.5 meters, wading), and a qualitative assessment of beach and splash-zone debris. In 2016, these efforts were largely transferred to local units of government with WRD providing support for quality control purposes.

Figure 8. Lake Erie beach sites that have been sampled by the WRD for microcystin.

GREAT LAKES COASTAL WETLAND MONITORING

The WRD participates as a co-Principal Investigator on the Great Lakes Coastal Wetland Monitoring effort, which implements intensive monitoring of over 1,000 coastal wetlands throughout the Great Lakes Basin. This project was funded through the GLRI at a cost of $10 million for five years (2010-2015) and has been granted an additional $10 million to be continued through 2020. This large-scale monitoring effort, which includes over 17 partner organizations from universities and government agencies coordinating to monitor wetlands throughout the Great Lakes basin, including Canada, is the first of its kind and will provide the first comprehensive findings of Great Lakes coastal wetland condition and the basis for trends analysis in the future. The findings of this project will inform wetland policy, restoration planning, funding prioritization, and protection goals for government and tribal agencies, conservation organizations, and landowners in the future.

NATIONAL MONITORING

The NCCA, the NARS assessment of coastal waters, is designed to help the USEPA and its partners provide regional and national statistically-valid estimates of the condition of the nation's nearshore waters, including the Great Lakes. The WRD was awarded the FY 2009 Section 106 Monitoring Initiative grant for the 2010 field assessment year. All 107 sites (and 10 revisits) were successfully surveyed. While many sites were surveyed solely by WRD staff, assistance from crews with the USEPA Lake Guardian and the MDNR Lake Char was appreciated and extremely helpful to complete the assessment. The WRD was again awarded the FY 2014 Section 106 Monitoring Initiative grant; however, due to time constraints the majority of the field work was performed by the technical services contractor. The WRD is using the "Monitoring Strategy Implementation" funds from the FY 2014 federal Section 106 Monitoring Initiative grant to identify whether NCCA data can be used in Michigan's Integrated Report assessment methodology. This project began in January 2015 and is scheduled to be complete in time to incorporate decisions into the WRD assessment methodology for the 2018 Integrated Report.

Lake Guardian offshore of Sleeping Bear Dunes
– photo, courtesy of Bob Day, 2010

PROGRAM SUPPORT

Many WRD monitoring activities directly support Great Lakes programs established under the binational Great Lakes Water Quality Agreement (GLWQA). Amended most recently in 2013, the GLWQA expresses the commitment of Canada and the United States to restore and maintain the chemical, physical, and biological condition of the Great Lakes ecosystem. The basin's state, provincial, and tribal governments have long been important partners in implementing the GLWQA. Two major program areas under the GLWQA are the AOCs and

LAMPs. Related Great Lakes efforts include the development of Great Lakes indicators and coastal assessments. Contributions to these activities by WRD staff include assisting with environmental and ecological data collection and assessment, as well as planning and reporting.

AOC

The United States and Canadian governments identified 43 areas on the Great Lakes that had serious water quality problems known to cause BUI of the shared aquatic resources. These areas have been formally designated by the two governments as AOCs. Fourteen of the 43 total AOCs were in Michigan (Figure 9); note that two (Deer Lake and White Lake) have been delisted. Each AOC has an associated Remedial Action Plan to guide restoration activities related to one or more of the possible 14 BUIs, which are caused by a detrimental change in the chemical, physical, or biological condition of the water body. Progress made within each AOC is reported in Remedial Action Plan updates. The WRD monitoring staff works with the Office of the Great Lakes AOC coordinators and representatives of local public advisory councils to identify monitoring opportunities to support the BUI removal process. For example, WRD monitoring of contaminated sediments is used to assess concentrations and trends and ultimately is used to support the removal process for BUIs. Site-specific monitoring needs may change over time and thus a degree of flexibility is required to ensure progress. See Table 7 for a list of the BUIs identified by the GLWQA.

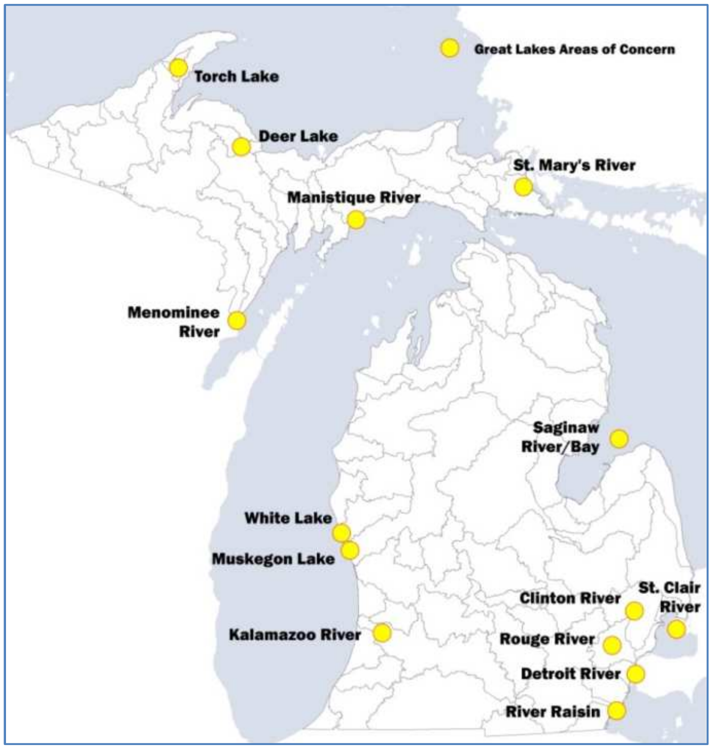


Figure 9. Michigan's initial 14 AOCs. Please note Deer Lake and White Lake were delisted in 2014.

Table 7. List of BUIs.

Restrictions on fish and wildlife consumption
Tainting of fish and wildlife flavor
Degraded fish and wildlife populations
Fish tumors or other deformities
Bird or animal deformities or reproductive problems
Degradation of benthos
Restrictions on dredging activities
Eutrophication or undesirable algae
Restrictions on drinking water consumption or taste and odor problems
Beach closings
Degradation of aesthetics
Added costs to agriculture or industry
Degradation of phytoplankton and zooplankton populations
Loss of fish and wildlife habitat

Table 8 shows the progress within each AOC. In 2006, in an effort to assess the status of individual BUIs, direct restoration efforts, and develop benchmarks for measuring their success, the MDEQ developed the Guidance for Delisting Michigan's Areas of Concern. This document: (1) provides guidance to AOC communities about the state's process for removing BUIs and delisting AOCs; and (2) identifies specific quantitative or qualitative criteria the state will use to determine when BUIs have been restored. The *2010 Strategy for Delisting Michigan's Areas of Concern* is a companion document to the guidance that addresses all identified BUIs within each AOC and actions needed to remove BUIs and delist AOCs, establishes AOC program priorities, and sets resource allocations in the AOC program.

LAMPs

The LAMPs are focused on broader, basin-wide issues for each Great Lake. They are the primary mechanism for federal, state, provincial, and tribal governments to establish shared goals, identify threats and priorities, take coordinated action, and monitor results. With the MDEQ as lead, the state of Michigan participates in LAMP work groups and committees for Lakes Erie, Huron, Michigan, and Superior. Several MDEQ water monitoring programs support ongoing LAMP efforts and contribute to data collections, including the water chemistry monitoring along the Great Lakes Connecting Channels and Saginaw and Grand Traverse Bays, and the fish contaminant monitoring, which includes Great Lakes fish.

There is WRD staff who participates in groups that represent specific lakes, such as the Lake Michigan Monitoring Coordination Council (LMMCC). The WRD has one staff person who sits on the LMMCC and serves to back up Michigan’s co-chair as needed (The other co-chair representative is from Wisconsin). The WRD recently provided support to the LMMCC through a GLRI grant that expired in June 2016. The work plan included three distinct components:

1) Support the LMMCC and its nearshore monitoring work group ($70,000)
2) Michigan-specific report using the 2010 NCCA data ($75,000)
3) Participation in Great Lakes monitoring planning ($78,658)

Through the Cooperative Science and Monitoring Initiative, which is coordinated via the LAMP process, governments develop and implement a monitoring campaign for each Great Lake on a five-year rotating basis. It is the WRD’s intent to be involved in this effort for all Great Lakes with Michigan shoreline; however, current participation is largely limited to Lake Michigan. The WRD recognizes this is a ***gap*** in our monitoring program and plans to expand its involvement as time allows. Another ***gap*** is the lack of an adequate vessel for monitoring large water bodies. A Great Lakes worthy vessel would allow WRD staff to fill these monitoring gaps. With sediment coring equipment the WRD would be able to assist the Great Lakes Legacy Act program and fill data gaps as needed. The WRD would also be able to assist the AOC program with BUI delistings and additional sampling opportunities that arise in the future.

Table 8. Michigan AOC BUI Progress. Adapted from the MDEQ, Office of Great Lakes, Web page last updated September 27, 2016.

Area of Concern	Restrictions on fish and wildlife consumption	Degradation of benthos	Loss of fish and wildlife habitat	Restrictions on dredging	Beach closings	Degradation of fish and wildlife populations	Degradation of aesthetics	Eutrophication or undesirable algae	Bird or animal deformities or other reproductive problems	Restrictions on drinking water consumption or taste and odor problems	Fish tumors or other deformities	Tainting of fish and wildlife flavor	Added costs to agriculture or industry	Degradation of phyto- or zooplankton populations	**Original Total**	**Remaining Today**
Saginaw Bay/River	☐	☐	☑	☐	☐	☐	☐	☐	☐	☑		☑		☐	12	9
Detroit River	☐	☐	☐	☐	☐	☐	☐		☐	☑	☐	☑			11	9
St. Clair River	☐	☑	☐	☑	☑		☑		☐	☐		☑	☑		10	4
St. Marys River	☐	☐	☐	☐	☑	☐	☑	☐	☑		☐				10	7
Muskegon Lake	☑	☐	☐	☑	☑	☐	☐	☐		☑					9	5
River Raisin	☐	☐	☑	☐	☑	☑	☑	☑	☐						9	4
Rouge River	☐	☐	☐	☐	☐	☐	☐	☐			☐				9	9
Clinton River	☐	☐	☐	☐	☐	☐	☐	☐							8	8
Kalamazoo River	☐	☐	☐	☐	☑	☐	☑		☐						8	6
White Lake	☑	☑	☑	☑		☑	☑	☑		☑					8	0
Menominee River	☐	☐	☐	☐	☑	☐									6	5
Manistique River	☐	☑	☑	☐	☑										5	2
Deer Lake	☑							☑	☑						3	0
Torch Lake	☐	☐									☑				3	2
Original Total	14	13	12	12	11	10	10	8	7	5	4	3	1	1	**111**	
Remaining Today	11	10	8	9	4	8	5	5	5	1	3	0	0	1		**70**

☐	Beneficial Use Impaired
☑	Beneficial Use Restored
	Not Applicable to this Area of Concern

Drinking Water
There are over 70 drinking water intakes in Michigan with the majority located in the Great Lakes and Connecting Channels. R 323.0100(8) of the Part 4 Rules, states the public water supply designated use must be met, "at the point of water intake and in such contiguous areas as the department may determine necessary for assured protection." The rule further states that, "waters of the Great Lakes and connecting waters shall meet the human cancer and human noncancer values for drinking water established pursuant to R 323.1057(4)."

The 2012 Integrated Report was the first time the WRD used raw water intake chloride data from water treatment facilities to evaluate this use. Chloride concentrations were used per R 323.1051(2), which states that, "waters of the state designated as a public water supply source shall not exceed 125 mg/L of chlorides as a monthly average, except for the Great Lakes and connecting waters, where chlorides shall not exceed 50 mg/L as a monthly average."

The 2016 Integrated Report assessment methodology calls for a comparison of ambient water data collected within drinking water Critical Assessment Zones to drinking water Maximum Contaminant Levels as a screening process to determine where additional monitoring may be useful. The Critical Assessment Zones is a calculated radius surrounding the intake using a two-factor equation to define the sensitivity of the intake. A typical Critical Assessment Zone can vary from a 1000-3000 foot radius. Even with this methodology, the problem follows that limited data are available. Facilities rarely monitor ambient water near the intake because drinking water Maximum Contaminant Level numbers are end-of-treatment values. The Source Water Protection Program in the Office of Drinking Water and Municipal Assistance focuses primarily on groundwater. Data collected within a Critical Assessment Zone by the WRD could be used; however, the likelihood that monitoring stations fall within these Critical Assessment Zones is small, unless requested through the targeted monitoring request process.

GREAT LAKES MONITORING SUMMARY AND GAPS

The WRD recognizes current and future gaps in monitoring efforts in Michigan's Great Lakes. Resource needs and monitoring gaps related to Great Lakes monitoring are discussed below under each Strategy goal and are also shown in Table 9:

1) Assess the current status and condition of waters of the state and determine whether WQS are being met.

   The WRD assesses water quality status and makes WQS determinations in the Great Lakes using water chemistry, *E. coli*, and fish tissue data. Routine water chemistry status monitoring is currently limited to the Connecting Channels, Saginaw Bay, and Grand Traverse Bay. Pathogen monitoring is successfully performed at Great Lakes beaches each year, and fish tissue analysis on edible portions is used to assist the MDHHS in updating their fish consumption advisories.

   - ***Gap***: Great Lakes beach and WCMP monitoring are supported through FY 2017 and 2018, respectively. In the near future, however, these programs will likely face substantial cuts. All Great Lakes beach grant dollars are from the federal BEACH Act, a program routinely threatened by federal budget cuts/elimination. The majority of the WCMP is funded with CMI-CWF dollars, which are expected to be fully expended after 2018. Consequently, future monitoring will likely be limited further rather than expanded.

- ***Gap***: The WRD currently does not have any Great Lakes biological indicators for either the coldwater fishery or OIALW designated uses. While there are no immediate plans to develop these indicators, the WRD is evaluating the potential for using NCCA data and would like to investigate the use of the MDNR Great Lakes fish community data to assess the coldwater fishery designated use.

- ***Gap***: The WRD does not currently have the capability to assess status and conditions in large waters that require a Great Lakes-worthy vessel with equipment for sediment collection and other deployment gear (e.g., crane, winch). However, the WRD is using Section 106 Monitoring Initiative dollars to retrofit a boat in storage for this purpose.

2) Measure spatial and temporal water quality trends.

   Spatial and temporal trends are evaluated for water chemistry in the Connecting Channels, Saginaw Bay, and Grand Traverse Bay, *E. coli* on Great Lakes beaches, fish tissue at ten Great Lakes stations, and wildlife contaminants in bald eagles and herring gulls.

   - ***Gap***: Both water chemistry and fish tissue data collection are supported with CMI-CWF, making the future of these programs a potential gap after 2018.

3) Evaluate the effectiveness of water quality restoration and protection programs.

   The WRD is currently the project manager on the Manistique River AOC Cleanup and assists with the Rouge River, Detroit River, and River Raisin AOCs.

   - ***Gap***: The loss of CMI-CWF will eliminate most of this support.

4) Identify new and emerging water quality problems.

   Currently, Saginaw Bay and Lake Erie beaches are sampled periodically for microcystin. Monitoring efforts for these waterbodies are evaluated annually.

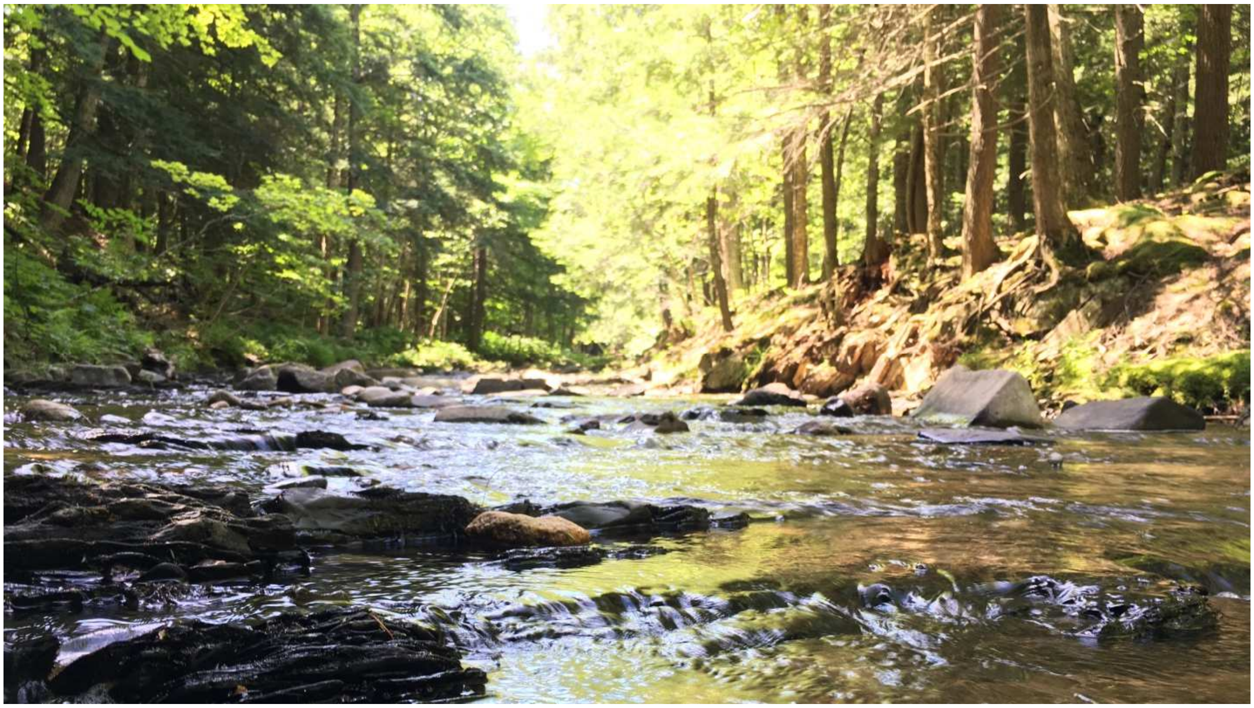
Note the WRD established a work group in January 2015 to determine whether data collected for the NCCA can be used to fill in monitoring gaps. Water chemistry, pathogen, biological, fish tissue, and sediment data are collected every five years during the NCCA. These data are used to report status and trends of nearshore waters in the USEPA NARS reports. While the goals of the NCCA are not to determine WQS attainment, the WRD is investigating whether any of these data can be used for this purpose. The WRD requested and was approved to use FY 2014 Section 106 Monitoring Initiative Strategy Implementation funds to evaluate whether NCCA data can be used in the assessment methodology for the Integrated Report development. The work group plans to complete their goals in time to submit any proposed changes or additions to the assessment methodology for the 2018 Integrated Report.

Note that AIS monitoring is not listed as a gap. Because the program does not have objectives associated with it to date, it is difficult to define where it belongs regarding the four goals of the Strategy. AIS will likely fall in the status goal, but whether for established or emerging species or both has not been determined. This issue will likely be incorporated into all four goals of the Strategy, but how specifically will be determined by the Aquatic Biologist Specialist.

Table 9. Summary of monitoring efforts, water quality indicators, and gaps for designated use determinations in Michigan's Great Lakes.

Designated Use	WRD Efforts to make WQS determinations.
Agriculture, Navigation, Industrial Water Supply	These uses are assumed to be supported unless there is site-specific information indicating otherwise.
Warmwater Fishery	Not applicable.
OIALW	Sampling conducted in Connecting Channels, Saginaw Bay, and Grand Traverse Bay. • Toxic substances (R 323.1057): typically low-level and other heavy metals • pH (R 323.1053) ***Gaps***: Great Lakes water chemistry monitoring is limited to the Connecting Channels, Saginaw Bay, and Grand Traverse Bay; there are currently no biological indicators to assess this use in the Great Lakes.
PBC and TBC	*E. coli* sampling in Great Lakes Beaches and on major tributary mouths where they enter the Great Lakes. • Microorganisms (R 323.1062)
Fish Consumption	Water chemistry sampling conducted in Connecting Channels, Saginaw Bay, and Grand Traverse Bay and fish edible portion monitoring. • Fish tissue criteria • Toxic substances (R 323.1057): typically low-level mercury and PCBs
Coldwater Fishery	Dissolved oxygen and temperature rules apply
Public Water Supply	Review data from public water supply facilities. Note that assessment methods geared towards chloride data were incorporated starting with the 2012 Integrated Report. • Dissolved solids (R 323.1051) ***Gap***: There is extremely limited monitoring where the use applies and WQS suitable to assess this use are limited.

RIVERS AND STREAMS



West Branch Huron River in Baraga County, 2016

ROUTINE MONITORING

Water Chemistry

Water chemistry monitoring objectives in rivers and streams are:

1) Determine the current water quality and WQS attainment of core indicators with numeric and narrative criteria in Michigan's rivers and streams.
2) Determine spatial and temporal water quality trends in Michigan's rivers and streams.
3) Evaluate program effectiveness and provide program support (e.g., TMDL program, NPS program, and the AOC and LAMP programs in the Office of Great Lakes).
4) Evaluate emerging contaminants in Michigan's rivers and streams.
5) Provide data for the WRD Measures of Success regarding total mercury WQS attainment in rivers and streams.

WCMP

Historically, water chemistry data were collected from 27 tributaries at 31 fixed stations to evaluate water quality changes over time and measure nutrient loadings to the Great Lakes. However, the tributary monitoring, which began in 1998, was eliminated after the 2013 field season when it was determined that objectives of that activity had been met. This effort provided over 15 years of monitoring data, both concentration and loading, at downstream locations of many rivers including within AOC boundaries.

The WRD probabilistic water chemistry monitoring, which began in 2005, includes 250 randomly chosen river and stream sites (Figure 10) sampled at a rate of 50 sites each year over a 5-year period. In addition, five of each year's 50 sites are carried over and sampled the following year to give the WRD the ability to evaluate intrinsic variation. Parameters analyzed are shown in Table 10.

In 2009 and 2011-2013, the WRD added *E. coli* monitoring to determine the extent of this pathogen in rivers and streams. Because this program is set up with the "statewide project design," statewide conclusions can be made each year, keeping in mind the confidence about the central tendency conclusion may be larger than desired with just one year of data.

The WCMP data are used to assess the Measure of Success outcome that total mercury in all ambient stream waters will meet the WQS by 2020. The progress on this objective was rated "fair" in the most recent Measures of Success document.

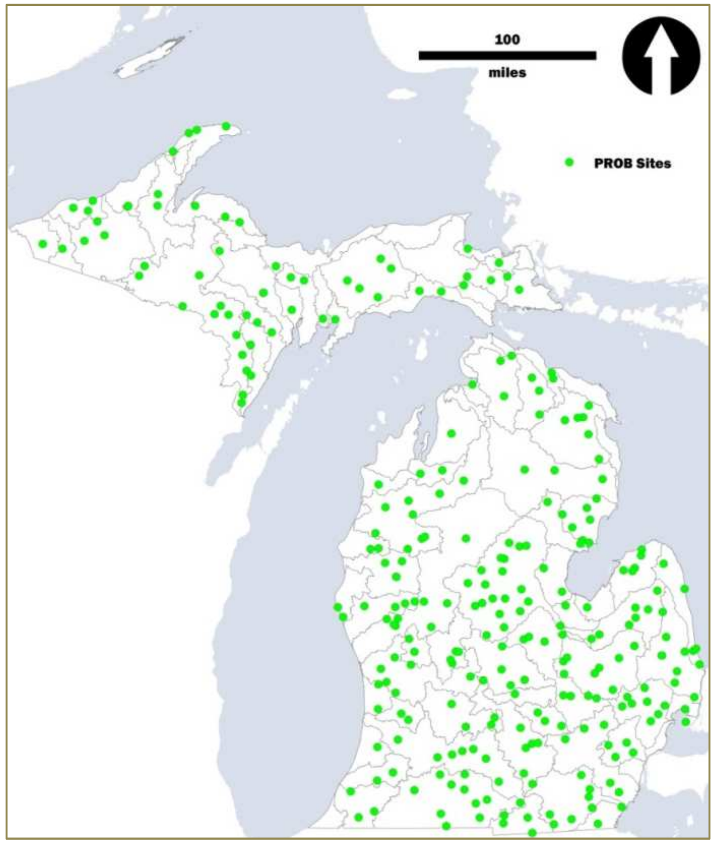


Figure 10. Probabilistic site locations for the WCMP.

Table 10. Analytical methods, quantification levels, and units of measurement. SM = Standard Method; mg/L = milligrams per liter; ug/L = micrograms per liter; ng/L = nanograms per liter.

Parameter	Analytical Method	Quantification Level	Unit
Phosphorus, Total	365.4	0.005	mg/L
Hardness	Calculated	5	mg/L CaCO3
Calcium	7140/3111B SM	1	mg/L
Magnesium	7450/242.1	1	mg/L
Conductivity – Field	Field probe[2]		umhos/cm
Dissolved Organic Carbon	5310C SM	0.5	mg/L
Chlorides	325.2	1	mg/L
pH – Field	Field probe[2]		pH S.U.
Temperature – Field	Field probe[2]		°C
Dissolved Oxygen – Field	Field probe[2]		mg/L
Suspended Solids, Total	2540D SM	0.5	mg/L
Copper, Total	1638[1]	0.1	ug/L
Chromium, Total	1638[1]	0.19	ug/L
Lead, Total	1638[1]	0.014	ug/L
Mercury, Total	1631	0.45	ng/L

[1]Method is consistent with USEPA Method 1638.

[2]Multiparameter YSI Model 556.

TMDL Development/Implementation

A water quality concern identified through the Integrated Report process may require further collection water chemistry monitoring data to determine whether a TMDL is an appropriate action. Monitoring often occurs during biological condition monitoring or by designing a special study to be carried out by WRD or GLEC staff.

Pathogens

The bacteria monitoring objectives in Michigan's rivers and streams are:

1) Assess the current water quality and WQS attainment regarding pathogens in Michigan's rivers and streams.
2) Support the NPS program by performing special studies such as pre- and post-BMP implementation projects (e.g., cattle exclusion).
3) Monitor *E. coli* to support the Measure of Success outcome that all rivers and streams will meet the TBC WQS.

In 2009 and 2011-13, *E. coli* was incorporated into the probabilistic component of the WCMP to better understand the spatial nature of bacteria problems in Michigan's rivers and streams. The short holding time (6 hours) was a substantial logistical challenge that was met with an on-site laboratory. WQS determinations for the TBC designated use were not part of this project because the sampling design for this program (four sampling events annually) did not meet the assessment methodology requirements. This project showed that *E. coli* results met the WQS at an estimated 60% of Michigan river and stream miles at the time of sampling – which did not equate to Integrated Report listing for nonattainment due to the collection method (MDEQ, 2014b). This did, however, lead to follow-up targeted investigations where appropriate.

Outside of that WCMP effort for *E. coli* monitoring, bacteria impairments in rivers are generally found through targeted monitoring conducted by the MDEQ in response to citizen concerns, by local county health departments and other agencies, and by grantees. According to the 2014 Integrated Report, of the 76,419 river miles in Michigan, 7,344 have been assessed for TBC. Of those 7,344 miles, only 111 were identified as meeting this designated use (MDEQ, 2014a).

Biological Condition

The objectives of biological condition monitoring in Michigan are:

1) Determine the statewide percentage of wadeable and nonwadeable rivers and streams that meet the OIALW designated use.
2) Determine whether macroinvertebrate P-51 scores are changing over time in wadeable rivers and streams; and in response to water quality restoration and protection actions (e.g., BMPs).
3) Provide program support and effectiveness monitoring.
4) Measure of Success: ensure the condition of the state's wadeable streams does not degrade, such that there is no statistically significant increase in the percent of streams rated "nonattaining," and no statistically significant decrease in streams rated "attaining."

Watershed Surveys

Habitat survey of an Upper Peninsula river, 2012.

Watershed surveys are performed using the five-year basin cycle design described in Section 1. Until 2004, only wadeable streams (macroinvertebrates and fish) were surveyed by the WRD. Today, the WRD also has the equipment to perform nonwadeable surveys (macroinvertebrates only). Biological assessment for water quality status and WQS attainment (OIALW designated use), spatial and temporal trends, programmatic support, and emerging issues are all part of these evaluations. Also, targeted non-biological work is often added to these assessments, such as water chemistry collection or sediment chemistry, as requested through the targeted monitoring process (See Targeted Monitoring in Section One). Preliminary AIS observations were added to these surveys in 2013 and continue today to assist the AIS Unit in developing their monitoring priorities (See AIS Heading below).

Historically, biologists designed work plans that would assess 80% of each watershed. In 2006, site selection was redesigned to use a probabilistic approach. This statistical design was suggested by the USEPA as an approach that would: (1) reduce sampling effort; and (2) allow the WRD to extrapolate the results to make regional determinations, like statewide or watershed. Designated use determinations using the 80% coverage method were limited to reaches that contained sampling locations (e.g., a segment of a 12-digit HUC determined using best professional judgement).

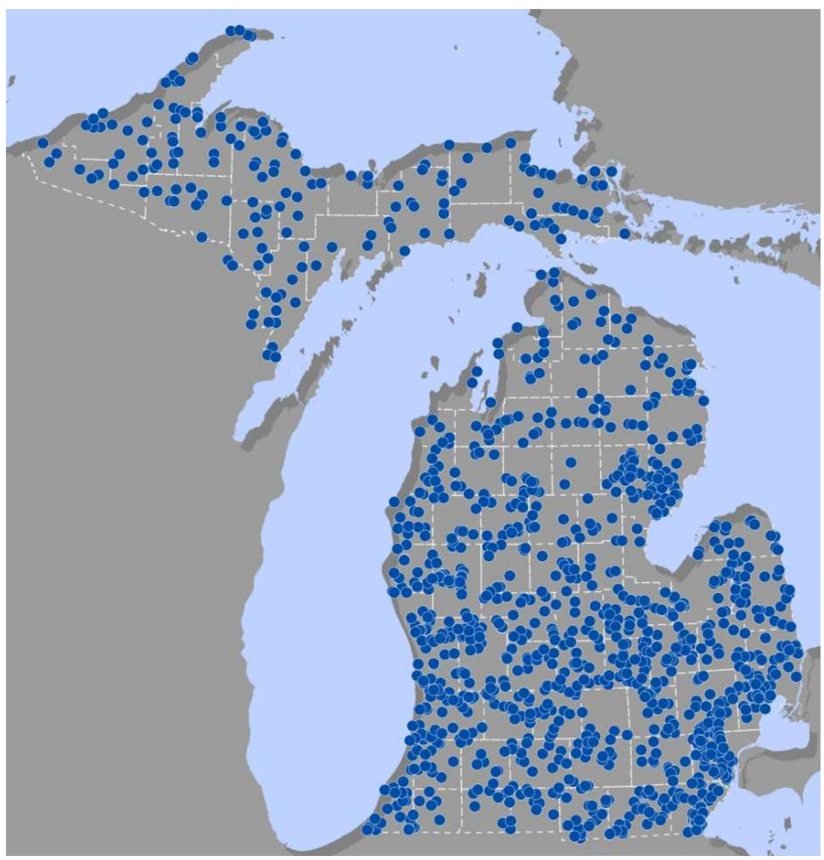


Figure 11. River and stream probabilistic survey locations for biological condition, 2006-2010.

Between 2006 and 2010 (the first 5-year basin cycle using a probabilistic approach), biologists visited 1,192 wadeable and nonwadeable river and stream sites for status sampling (Figure 11). A portion of those wadeable sites were randomly selected to become trend sites that will be sampled during their basin-year as long as this trend program is in place (n=177 for statewide analysis with an additional 92 selected to determine trends at the watershed level in select 8-digit HUCs). These results were used to determine the sample size needed for the second basin-cycle status effort that would produce a desired precision of 15% with a 95% confidence interval within all watershed units (MDEQ, 2015b). The total number for status sampling locations over the 5 years was 650 (status and trend effort was 919 sites including the 269 trend sites that were sampled).

In 2016, the WRD evaluated the distribution of monitoring efforts and determined that river and stream sampling should be reduced to meet other programmatic goals. It was decided that trends will continue to be evaluated at the state level and within many watersheds; however, status sampling will be no longer include a watershed component. The sample size for determining the statewide biological condition in rivers and streams for 2016-2020 is 250 sites. This is a significant reduction in effort that will provide staff with opportunities to address monitoring goals in other water body types. Note that trends will first be calculated in 2020 when three cycles of biological surveys have been completed.

For waters listed as impaired, the TMDL development process requires extensive monitoring to document the cause(s) of impairment, identify the sources of the problem, and quantify the loads. Typically, the biological indices are limited to the macroinvertebrate community to allow staff to visit more sites a year.

The USEPA recommends that states routinely monitor at least two biological communities at all sites. The WRD currently monitors benthic macroinvertebrate community at all biological survey sites, but the fish community is only assessed at a fraction of these locations – typically less than 10% of all survey locations each year. In 2012, the WRD began to use fish community data collected by the MDNR (as part of their status and trend program) to augment fish community assessment data. ***Gap***: the WRD recognizes the need to further evaluate the frequency of monitoring fish communities in rivers and streams.

Wadeable Procedure

The WRD has a long-standing procedure that uses a rapid multi-metric bioassessment technique, P-51, to evaluate the macroinvertebrate and fish communities and habitat quality in wadeable rivers and streams (MDEQ, 1990). The macroinvertebrate portion of the procedure calls for two biologists to sample all available habitats proportionally with D-frame nets for 20-30 minutes or until all habitats are sampled.

South Branch Escorse River
– photo courtesy of Kevin Goodwin (2001)

Historically, the macroinvertebrate community was evaluated by taking a subsample of 100 organisms found across all habitats. This was evaluated by the WRD in 2005 and 2007, and it was determined that a subsample of 300 individuals (+/- 60) would be a more prudent approach to assess the macroinvertebrate community. Today, biologists take subsamples of macroinvertebrates collected (which are kept in a 5-gallon bucket) until the desired count is reached. Biologists generally estimate three to four sites can be completed in one field day, depending on site access, distance between sites, and site conditions (e.g., sites with low density macroinvertebrate counts and/or sites with high fine particulate organic matter take longer to count).

P-51 was developed specifically for use in flowing waters, which applies to all wadeable flowing waters, including small water bodies with sufficient gradient and water in the channel to create flow. Just like P-51 is not suitable in stretches of rivers and streams with no flow, it is not suitable for headwaters with no flow and/or limited water. ***Gap***: the WRD needs to better define a cutoff point when P-51 is not appropriate and evaluate the extent of headwater miles that are not currently assessed. The WRD understands the USEPA and other agencies have developed methods to evaluate water quality in small headwater streams (e.g., less than 1.0 square mile of catchment); however, the applicability of this to Michigan cannot be evaluated until the WRD determines how to define headwaters and the suitability of P-51 to these waters.

Nonwadeable Procedure

Approximately 5% of the river and stream sites that are probabilistically chosen each year are nonwadeable. The procedure to assess nonwadeable rivers, which uses a multi-metric index for site assessment, was first used in 2005. This procedure, P-22, was finalized in 2013 (MDEQ, 2013a). Nonwadeable sites were completed by GLEC staff until 2014 when WRD staff was able to use inflatable boats purchased as part of the NLA to make this part of routine in-house monitoring efforts.

Like P-51, this is a two-person effort. Biologists sample all available shoreline habitat at 11 transects using a D-frame net. Macroinvertebrates are composited and subsampled, counting 25% of the total sample. Individuals are identified on-site to lowest practical taxa level, typically family for insects. Biologists estimate one site a day to be completed when their work plans are written.

Other Agency Biological Data

The MDNR-FD monitors fish populations from rivers and streams as part of their status and trend program. The WRD created a work group with MDNR-FD staff to evaluate how each agency's data could be used to fill in the other's monitoring gaps. Starting in the 2012 IR cycle, FD status and trend community data are assessed using the warmwater and coldwater fishery definitions in the Part 4 Rules. These data are reviewed independently by two WRD biologists who use the target species in R 323.1044 to determine whether species composition is reflective of a balanced, integrated, and adaptive fishery community. Stream reaches are listed as meeting designated uses when both biologists agree the fish community at the sites meets the definition. If the biologists do not agree or both determine the fish community may not meet the designated use, the stream reach is listed as needing further evaluation, prompting WRD staff to follow up with P-51.

Fish Contaminants

Fish tissue is analyzed for PCBs, mercury, and a suite of industrial chemicals and pesticides such as DDT. Selected samples may be analyzed for dioxins and dioxin equivalents; others may be analyzed for emerging contaminants such as perfluorinated compounds, PBDE, or selenium.

The objectives for fish contaminant monitoring in rivers and streams are:

1) Determine the status of the fish consumption designated use for the Integrated Report.
2) Support MDHHS fish consumption advisories.
3) Investigate emerging contaminants as needed.
4) Evaluate remediation efforts and impacts from point sources using caged fish studies.
5) Provide data for the Measures of Success document.

Edible Portion Monitoring
The WRD collects fish from selected locations each year to measure contaminant levels in edible portions (generally the fillet). If the concentration of any contaminant exceeds a MDHHS action level, a consumption advisory is issued by the MDHHS and the affected water body is determined to be in nonattainment with WQS by the WRD.

Measures of Success for fish consumption relate to rivers and streams, Michigan's Great Lakes, and inland lakes. These are: reduce mercury levels in edible portions of Great Lakes, inland lakes, and stream fish to below 0.35 mg/kg by 2020; reduce PCB levels in edible portions of Great Lakes, inland lakes, and river fish to below 0.05 mg/kg by 2025; and by 2025, achieve an average concentration of 0.53 ng/kg dioxin toxic equivalent levels in fish in the Saginaw River and Saginaw Bay. More details are provided above under the Fish Contaminant heading in the Great Lakes section.

Whole Fish Trend Monitoring
The WRD has established 22 fixed stations to measure temporal trends in bioaccumulative contaminants in fish tissues. None of the stations are in free-flowing streams; however, five sites are established in impounded river reaches. Carp are used as the sentinel species in those impoundments and are collected every three to five years. The parameters for this monitoring activity are listed in Table 4.

Caged Fish Studies
Caged fish are routinely used to identify potential sources of bioaccumulative contaminants in rivers (Objective 5). Cages are placed at various locations along a river or its tributaries. After 28 days cages are retrieved and the fish tissues analyzed for the parameter(s) of interest. Concentration differences in fish among the cages, if such differences are found, can indicate where elevated levels of the contaminant may be in the watershed.

AIS

In 2013, AIS inspections were limited to a special study project that included a subset of P-51 surveys. The objective of "adding-on" these observations to a small number of P-51 surveys was to determine its feasibility (e.g., can staff correctly identify AIS, does the addition of this inspection increase the field time beyond reasonable for rapid bioassessment surveys). In all, 13 locations were assessed. The response from those surveys led the addition of AIS inspections at all P-51 locations for the 2014 field season and has continued.

Beginning in 2016, many special projects were put in place regarding AIS. These included the continuation of snorkeling in large inland lakes to determine its practicality as a technique for early detection and numerous evaluations in rivers and streams for known AIS populations that needed to be mapped for extent.

Wildlife Contaminants

Bald eagle monitoring provides coverage for the major river systems in Michigan. Active bald eagle breeding areas are well distributed across the Upper Peninsula and northern Lower Peninsula of Michigan. Please see the Wildlife Contaminants in the Great Lakes Section for details on this program.

Sediment Chemistry

Sediment inquiries from the targeted monitoring request process are generally incorporated into watershed surveys. Biologists collect sediment as appropriate and submit samples to the MDEQ Laboratory or another laboratory if necessary. Sediment indicators depend on the known and/or suspected sources of contamination. Results are included in watershed survey reports and are used to determine if the location needs further investigation of a possible problem.

The WRD currently administers or provides support for projects on the Manistique River, Detroit River, Rouge River, and River Raisin. ***Gap***: The WRD does not have the capability of monitoring large rivers for sediment at this time. See the Sediment Chemistry in the Great Lakes Section for details.

Geomorphology

Channel morphology surveys consist of cross-section measurements, longitudinal profiles, pebble counts, and BEHI. Studies are performed to assist pass-through grantees with design and effectiveness assessments of projects and to support permit programs.

SPECIAL PROJECTS

Climate Change

The USEPA Region 5 Regional Monitoring Network for rivers and streams began field monitoring for climate change in 2016. The USEPA is asking state and tribal agencies to assist with site determination and perform monitoring. Annual macroinvertebrate monitoring is requested at a minimum; water chemistry sampling, fish collection, and qualitative habitat monitoring are expanded elements for a comprehensive assessment. Participation in the RMN is voluntary and there is no funding provided for this project. While the WRD agrees that climate change monitoring is an important element to investigate and consider for future routine monitoring, it is uncertain whether this effort is the best course of action for climate change monitoring in Michigan. Staff from the WRD worked with the USEPA and its contractors to identify and quality assure locations for this effort in 2015 and 2016. In 2016, one site was surveyed for macroinvertebrates using RMN methods. Decisions will be made to determine whether the WRD will move forward with more sites and more monitoring elements in the future or develop a method that better fits Michigan's needs. ***Gap***: Depending on the decisions made by the WRD, a date cannot be projected when climate change will be incorporated into routine monitoring, however the inclusion of climate change monitoring, and not limited to rivers and streams, is considered a gap in the Monitoring Strategy.

Biological Monitoring Reference Sites

Staff is using Section 106 Monitoring Initiative Monitoring Strategy Implementation dollars to research the reference sites used for the development of P-51 biological condition scoring. These sites were chosen between 1990 and 1991 and the protocol was developed using earlier versions of the procedure. Staff will determine whether the reference sites continue to be appropriate, need to be revisited, or redrawn. This project, which is part of a larger effort to evaluate P-51, is expected to be complete in 2017.

Biological Methods Comparison

Macroinvertebrate scores from the WRD's P-51 and USEPA's NRSA methods were compared to determine whether they were correlated. NRSA results have historically found rivers and streams to be in worse condition throughout the Upper Midwest than expected by the WRD (this "Upper Midwest" region is defined by the USEPA and is delineated for the purposes of this assessment only). This study was performed to determine what, if any, similarities/ differences were present between these multi-metric indices and determine if next steps are needed to evaluate P-51's effectiveness.

NATIONAL MONITORING

The NRSA, part of the NARS, is designed to help the USEPA and its partners provide regional and national statistically valid estimates of the condition of rivers and streams. This assessment was performed in 2013 and 2014. The WRD conducted the field work at all national sites located in Michigan. The WRD originally intended to use "Monitoring Strategy Implementation" funds to complete additional sites to perform a state-scale assessment; however, this effort was withdrawn due to budget cuts from the federal sequestration.

The WRD has a long-standing rapid biological assessment procedure, P-51, to evaluate rivers and streams in Michigan that yields very different results from NRSA methods. The WRD is currently evaluating the cause of this discrepancy. The next NRSA is scheduled for 2018 and 2019. Participation will depend on a number of factors, including other monitoring responsibilities, financial considerations, and possibly the results of the comparative analysis.

PROGRAM SUPPORT

Special studies, within and outside of the five-year rotating basin watershed surveys, are conducted to identify waters that may not be attaining WQS, pinpoint potential causes and sources, and evaluate whether water quality protection activities have resulted in improvements. These types of projects are identified through the targeted monitoring request process.

TMDL Development/Effectiveness Monitoring

The WRD conducts special studies as needed to support the development and implementation of TMDLs, as required by Section 303(d) of the federal CWA. Lead watershed biologists request TMDL development monitoring through the targeted monitoring request process as a result of previous monitoring efforts. Depending on the pollutant, requests are carried out by biologists during watershed surveys, or special studies are written and carried out by biologists or GLEC staff.

Michigan is developing a statewide *E. coli* (bacterial) TMDL as the centerpiece of the TMDL Vision Prioritization Framework. The efficiencies gained through this process will enable efforts to be focused on implementing TMDLs in impaired water bodies where positive impacts on water quality can be made, rather than expending resources on producing TMDLs indefinitely.

NPDES
WRD Staff can request monitoring related to NPDES outfall locations through the targeted monitoring request process. Generally, requests are carried out during the watershed surveys. Often the lead watershed biologist and a biologist from Permits Section will perform surveys in these locations as the two-biologist team required by P-51 and other monitoring work.

In addition, there is continued concern about the release of untreated sewage from SSOs and CSOs into surface waters and the potential for environmental and public health impacts. Both SSOs and CSOs must be reported to the WRD by the responsible entity. The legislation that requires reporting also requires the responsible party to test the affected waters for bacteria, unless the local county health department waives such requirement. However, during the watershed surveys, biologists look for evidence of sewage discharge and refer findings to district staff for follow-up action.

NPS
Staff in the NPS unit request monitoring related to NPS pollution through the targeted monitoring request process. Depending on the objective, requests can be carried out during watershed surveys or as special studies. In 2015, WRD staff produced a protocol document (Rathbun et al., 2015) for conducting quantitative geomorphology, macroinvertebrate, periphyton, and fish surveys to assess the effectiveness of sedimentation BMPs. The first application of these protocols was the stamp sand remediation project on the Eagle River. Future applications could include channel creation or relocation projects and upland erosion control projects.

Stream Flashiness
Every five years WRD staff evaluates stream "flashiness" (the rapidity and duration of stream discharge response to runoff events) using flow records from over 300 current and historic USGS gages across Michigan (Fongers, 2012). Values for the Richards-Baker Flashiness Index are calculated for each year of record at each gage, and temporal trends are evaluated. Applications of stream flashiness data include hydrologic assessments for watershed management planning and evaluation of channel instability assessments.

Perennial Streams Assessment
A perennial streams determination procedure was developed by WRD biologists and MDNR staff in 2014 (MDEQ, 2014c) following a need for site-specific evaluations in the Water Withdrawal Program. Information used for this procedure can include previous water chemistry, temperature, or biological surveys; fish kill reports; discharge measurements, including zero-flow observations; stream order (2nd order and larger are typically perennial); or aerial imagery. If a desktop review cannot conclusively identify flow permanence, a field review is necessary. The intent of the field review is to quickly observe and document physical and biological conditions upstream and downstream of access points.

For consistency sake, determinations are made by a team of two or more trained staff either in the field (preferred) or by one staff member in the field followed by an office review by a different trained staff. Perennial stream determination requests are made, if possible, during the targeted monitoring request process and WRD biologists perform these evaluations as needed.

However, this procedure can be implemented any time during the year and does not require, but can include, in-stream sampling.

Drinking Water
Of the 70 plus drinking water intakes in Michigan, less than 10 are located in the rivers and streams. R 323.0100(8) states the public water supply designated use must be met, “at the point of water intake and in such contiguous areas as the department may determine necessary for assured protection.”

PASS-THROUGH GRANTS

Local Monitoring Grants (non-beach)
While there are currently projects in progress from recently awarded Local Water Quality Monitoring Grants, there are no future plans to offer these opportunities to local governments, universities, and nonprofit organizations. The final request for proposals for these grants was offered in FY 2015 in light of the near completion of CMI-CWF. Throughout the years $250,000 was typically available annually. Applications were reviewed by a team who sought input from appropriate WRD district staff, watershed biologists, and specialists. Grants were awarded to as many quality applications as possible (usually five to seven each year). These grants were a powerful tool to fund water quality concerns at the local level and allowed stakeholders to take charge and answer their own water quality questions. Losing the ability to award local monitoring grants is a monitoring ***gap*** that can only be reinstated with a new funding source.

Local Monitoring Grants (beach)
There are no beach grants for rivers and streams.

VOLUNTEER MONITORING

The objectives of volunteer monitoring in rivers and streams are:

1) Develop a sustainable volunteer monitoring program.
2) Train volunteers to ensure high quality data are collected that can be used as a screening tool to identify sites as needing further evaluation.

The MiCorps is a network of volunteer monitoring programs in Michigan. Created through Michigan Executive Order #2003-15, MiCorps assists the WRD in collecting and sharing water quality data for use in water resources management and protection programs. MiCorps staff provides training and technical support to grant recipients and other volunteer groups to ensure high quality data collection. These data are primarily used as a screening tool to assist WRD biologists with site selection in a watershed and support local activities.

Since 2005, the MiCorps has provided grant funding as part of the Volunteer Stream Monitoring Program to organizations interested in monitoring their streams and rivers. Each year, approximately $50,000 is made available to recipients for full and start-up grants through a competitive grant application process. Prior to 2015, grants were available only for benthic macroinvertebrate monitoring. Beginning in 2015, this process also included grants for road/stream crossings. Funding for this program is provided by the MDEQ under the CMI-CWF. Since 2005, a total of 44 full, 24 start-up, and 3 road/stream crossing grants have been awarded under the Volunteer Stream Monitoring Program, totaling more than $570,000 in grant funding to award recipients. The MiCorps also has an inland lakes volunteer program, the CLMP, which is discussed later in the Inland Lakes Section.

RIVERS AND STREAMS MONITORING SUMMARY AND GAPS

Routine monitoring in Michigan's rivers and streams has historically been fundamental in WRD field efforts. However, the WRD recognizes the importance of evaluating program strengths and weaknesses and strives to maintain a current scientific approach to monitoring. Resource needs and monitoring gaps related to rivers and streams are discussed below under each goal heading and are shown in Table 11:

1) Assess the current status and condition of waters of the state and determine whether WQS are being met.

   The WRD assesses water quality status and makes WQS determinations in rivers and streams annually using data from the WCMP, watershed surveys, and special projects. Pathogens are monitored where previous *E. coli* data have led to further assessment needs. The number of sites monitored each year for *E. coli* is highly variable, depending on funding availability and the number of requests made during the targeted monitoring request process. Fish tissue data collected in rivers and streams through the FCMP are used to assess WQS. While sediment chemistry is not directly used to determine WQS attainment, data collected are used as a trigger to see whether further investigation is needed.

   Regarding the macroinvertebrate community assessments in wadeable streams, an overwhelming percentage of rivers and streams in Michigan meet the OIALW designed use with P-51. The WRD is evaluating some aspects of P-51 to validate these findings are an appropriate reflection of WQS. Two studies are currently underway: (1) The comparison of P-51 and NRSA multi-metric scores to determine whether these methods yield similar results; and (2) Evaluate existing reference sites used to develop P-51 metric scores for wadeable rivers and streams to ensure these continue to function in the assessment of wadeable rivers and streams. The outcomes of these studies will help direct future efforts.

   - ***Gap***: The WRD recognizes that performing P-51 for the fish community would provide a second factor to assess biological condition, which is highly recommended by the USEPA. Currently fish are only assessed at approximately 10% of biological assessment locations each year. Performing P-51 for fish would increase the amount of time needed at a site; thereby, decreasing the number of other assessments staff could perform annually. This needs to be a factor in determining the best path forward.

WRD biologists on the Rifle River in Arenac County, 2014

- ***Gap***: According to the 2014 Integrated Report, only 10% rivers and streams have been assessed the TBC designated use (MDEQ, 2014a) while greater than 50% do not meet WQS. Michigan uses *E. coli* to assess the TBC and has recently lowered the duration of monitoring required to make a listing decision to allow more waters to be assessed with the same amount of resources. The MDEQ would need to secure a funding source to expand this assessment and meet the goal of assessing 100% of waters.

2) Measure spatial and temporal water quality trends.

   Temporal trends for water chemistry can soon be evaluated using the WCMP probabilistic sites on rivers and streams. The 2015 field season data represent the first round of third-cycle monitoring data. Because these data aren't collected by basin-cycle, and are instead selected statewide, a limited dataset is available to make trend determinations in water quality. Macroinvertebrate community trends in wadeable streams can be analyzed after 2020, when three complete five-year basin cycles have been completed.

   - ***Gap***: P-22 has not been evaluated for its ability to detect trends.

   Note the WRD recognizes integrating these programs could decrease sampling effort and allow for multi-stressor analysis. Preparations are in place to perform a cost/benefit analysis to migrate to this approach. The concern is that some data collected before a site location merger could become unsuitable for trend analysis.

3) Evaluate the effectiveness of water quality restoration and protection programs.

   Monitoring to evaluate water quality programs is often conducted through the targeted monitoring request progress. The WRD monitoring request form solicits surface water monitoring recommendations from all stakeholders, including those within MDEQ. While concerns can regard any surface water body type and pollutant, many in-house requests include data collection to support the TMDL, NPS, and NPDES programs.

   A perennial streams determination procedure was developed by WRD biologists in 2014 for the Water Withdrawal Program in the WRD. These requests are made, if possible, during the targeted monitoring request process and WRD biologists perform these evaluations as needed. Staff also assists the MDNR and MDHHS in fish contaminant collections.

   - ***Gap***: Monitoring support to Heidelberg University for long-term water quality at their River Raisin station, a fixed site in their Lake Erie tributary loading program has been used to evaluate the effectiveness of the Conservation Reserve Enhancement Program and other pollution control activities related to western Lake Erie basin. This gap is twofold, where: (1) monitoring is currently limited to one site, and (2) while the data for that location are critical for the western Lake Erie basin water quality effort, this support is funded by CMI-CWF, which is expected to be exhausted at the end of FY 2018.

4) Identify new and emerging water quality problems.

   Emerging issues are handled as they arise. Examples of monitoring includes adding selenium and *E. coli* monitoring to the WCMP probabilistic stations to understand statewide concerns, including AIS monitoring as an add-on to P-51 surveys to evaluate extent and determine whether biological assessments can easily adapt to include this parameter.

Note that AIS monitoring is not listed as a gap. Because the program does not have objectives associated with it to date, it is difficult to define where it belongs regarding the four goals of the Strategy. AIS will likely fall in the status goal, but whether for established or emerging species or both has not been determined. This issue will likely be incorporated into all four goals of the Strategy, but how specifically will be determined by the monitoring program specialist.

Table 11. Summary of monitoring efforts, water quality indicators, and gaps for designated use determinations in Michigan's Rivers and Streams.

Designated Use	WRD Efforts to make WQS Determinations
Agriculture, Navigation, Industrial Water Supply	These uses are assumed to be supported unless there is site-specific information indicating otherwise.
Warmwater Fishery	Sampling conducted at random and targeted sites. • P-51 fish community surveys • Dissolved Oxygen • Temperature (R 323.1069, R 323.1075) Secondary data: MDNR fish status and trend assessment data from rivers and streams. ***Gap:*** Fish sampling is performed at a limited number of wadeable sites due to time constraints; there is no indicator for fish in nonwadeable waters.
OIALW	Sampling conducted at random and targeted sites. • P-51 and P-22 macroinvertebrate community surveys in wadeable and nonwadeable rivers and streams • Water chemistry samples, typically low-level total mercury and other heavy metals (R 323.1057) • Plant nutrients (R 323.1060) • Physical characteristics (R 323.1050) (e.g., turbidity, suspended solids, oil films) ***Gaps***: Headwater stream efforts.
PBC and TBC	Targeted *E. coli* monitoring is performed where earlier data indicate a WQS exceedance has or may occur. • Microorganisms (R 323.1062)
Fish Consumption	Water chemistry and fish edible portion monitoring. • Fish tissue criteria • Toxic substances in water (R 323.1057): typically low-level mercury and PCBs
Coldwater Fishery	Sampling conducted at random and targeted sites in wadeable rivers and streams. • P-51 fish community surveys • Dissolved Oxygen • Temperature (R 323.1069, R 323.1075) Secondary data: MDNR fish status and trend assessment data from rivers and streams are reviewed. ***Gap***: Fish sampling is performed at a limited number of wadeable sites; there is no indicator for fish in nonwadeable waters.
Public Water Supply	Assessment methods geared towards chloride data starting with the 2012 Integrated Report. • Dissolved solids (R 323.1051) ***Gap***: There is extremely limited monitoring where the use applies.

Sylvania Wilderness Area, Crooked Lake, 2013

ROUTINE MONITORING

Water Chemistry

Trophic Status and Water Quality – Statewide Sampling

Statewide efforts were made from 2001-2010 to continue ambient water quality monitoring efforts originally initiated in 1979 for 729 public access lakes across Michigan. Water quality indicators included nutrients (various forms of nitrogen and phosphorus), chlorophyll *a*, water clarity (Secchi depth), color, dissolved oxygen, water temperature, specific conductance, pH, alkalinity, hardness, and major ions such as calcium, magnesium, sodium, and chloride. This effort, the LWQA, was implemented in cooperation with the USGS as part of the MDEQ 1997 Strategy.

> ***A Brief Overview***
>
> The MDNR-FD program uses a statistically-based design and standardized sampling methods for public inland lakes 10 acres and larger. Public lakes are defined as: (1) lakes with public access site; (2) lakes with pay ramps; and (3) lakes that connect to another water body and can be accessed by the public.
>
> The MDNR-FD works off a complete list of inland lakes in the state with the intent to visit all lakes over time. On average 25 are sampled each year, with one visit in May-June and a second visit again in August. Water chemistry sampling is limited to the August event. After each field season, the MDNR-FD continues to the next lakes on the list. Visit MDNR-FD Inland Lake Status and Trend Program for further details.

In 2014, efforts were renewed to monitor inland lakes in Michigan through a pilot study partnered with the MDNR-FD statewide status and trend program (see text box). The WRD visited a subset of the MDNR-FD status and trend lakes scheduled to be sampled in 2014. The WRD visited each lake for spring turnover in April-May and again in July. Water samples from July, along with the MDNR-FD August samples, were used to calculate the Trophic State Index for each lake. In addition, the WRD recorded temperature/dissolved oxygen profiles at each visit and performed shoreline habitat assessments in July only. The goal of this pilot project was to determine the feasibility of collaborating with the MDNR-FD to accomplish joint goals.

Specific WRD objectives for inland lake monitoring are as follows.

1) Assess the status of trophic conditions, water quality, and habitat of inland lakes.
2) Determine whether inland lake trophic conditions, water quality, and habitat are changing with time.

3) Support watershed, lake management, and regulatory programs and determine their effectiveness.
4) Identify high quality inland lakes.
5) Identify inland lakes that are not meeting WQS.
6) Identify emerging problems in inland lakes, including the presence and impacts of AIS.

Since, 2015, water chemistry sampling has expanded to a statewide effort by collecting water quality samples in the spring and early summer at all MDNR-FD status and trend sites (typically near 25 each year). Spring turnover sampling is compared with results from the 729 public access lakes sampled during the LWQA. Shoreline habitat data, limited aquatic vegetation surveys (protocols established during LWQA surveys at public access lakes), AIS surveys (primarily for aquatic plants, see Add-On to Statewide Sampling Efforts under the AIS heading below), and algal toxin sampling is performed during the early summer sampling event to complement the fish data collected by the MDNR-FD. The collection of an additional summer sample more accurately characterizes trophic state and increases confidence when making WQS decisions for the Integrated Report.

Trophic Status – Satellite Imagery

The WRD has partnered with the USGS over the years under a Joint Funding Agreement to use satellite remote sensing technology to predict water clarity. This effort produced five data sets: 2002, 2003-2005, 2007-2008, 2009-2010, and 2011. Predictive models used for this project required Secchi disk transparency data throughout Michigan, which were taken from field measurements recorded at CLMP lakes by volunteers and the public access lakes during the LWQA effort. Model development included 20-25 Secchi measurements for each of 14 satellite scenes that covered the entire state of Michigan. The predicted water clarity of approximately 4,000 inland lakes was determined. An overview of the program and a water clarity interactive map viewer are available at https://mi.water.usgs.gov/projects/RemoteSensing/.

Continued success of modeling efforts require a greater collaborative approach that will seek to use data collected by multiple agencies, including the WRD, MDNR-FD, Tipp of the Mitt Watershed Council volunteers, the National Park Service, Tribes, and other organizations that sample lakes. The most recent Joint Funding Agreement with the USGS was initiated in 2014 and combined 2014 data with earlier datasets to provide a 15-year record of Trophic State Index predictions, a sufficient number of years to establish a record of statewide water clarity and analyze for trophic status trends.

TMDL Lake Monitoring

WRD staff has completed 18 TMDLs through 2014 for inland lakes, addressing phosphorus (12), *E. coli* (5), and PCBs (1). Routine follow-up monitoring has been conducted at the first four lakes (Lake Allegan, Lake Macatawa, Ford Lake, and Belleville Lake) to have USEPA-approved phosphorus TMDLs. The monitoring objective is to assess progress toward attainment of the TMDL goals and to measure point source and NPS program effectiveness. The current WRD objectives for these TMDL Lakes are to achieve these total phosphorus targets by 2020: Lake Allegan (60 micrograms per liter [µg/L]); Lake Macatawa (50 µg/L); Ford Lake (50 µg/L); and Belleville Lake (30 µg/L).

Microcystin and Harmful Algal Blooms

The WRD established a work group with MDHHS staff to address issues related to algal bloom monitoring, response, and reporting. This group developed recommendations and procedures for harmful algal bloom monitoring that can, at a minimum, be incorporated into the inland lake statewide sampling/status and trend collaboration effort with the MDNR-FD. This group is preparing a work plan regarding harmful algal bloom monitoring in inland lakes. In addition, the WRD received $400,000 in technology funds in FY 2016 to support the deployment and use of technology to enhance harmful algal bloom monitoring capabilities.

Beach Monitoring

The WRD provides beach monitoring grants to local health departments to support and augment *E. coli* monitoring at inland beaches. Beaches are selected by local health departments based on public access and volume of use. These grants were first available in 2003 with the influx of CMI-CWF dollars and are now offered as two-year grants awarded in odd-numbered years. The last request for proposals grant package is expected to be available in FY 2017, after which it is expected CMI-CWF will be exhausted.

Pathogen monitoring objectives for inland lakes are:

1) Assess the current water quality and WQS attainment at inland lake beaches.
2) Support county health department monitoring efforts to determine whether beach water is safe for swimming through technical assistance and grant opportunities using CMI-CWF dollars.
3) Create and maintain a statewide database.

County health departments use the results to assess whether the TBC or PBC recreation designated uses are being attained and whether beach closings are necessary. Sampling procedures and allowable *E. coli* levels are defined in the Michigan Part 4 Rules. With regard to the TBC and PBC recreation, county health departments have primary responsibility in Michigan for beach monitoring.

Public beaches have been identified at 495 sites on inland lakes throughout the state. In 2015, monitoring was conducted at 184 inland lake public beaches in 38 counties. The number of inland beaches monitored since 2007 has ranged from a high of 269 to a low of 153 (MDEQ, 2016b). Monitoring typically yields several cases each year where contaminant sources are identified and remediation efforts are initiated.

Information regarding the statewide beach monitoring database, BeachGuard, can be found under Beach Monitoring in the Great Lakes section.

Biological Condition

The WRD does not conduct biological monitoring in inland lakes at this time, primarily because there are no established biotic integrity metrics for lakes. However, the WRD began using MDNR-FD status and trend inland lake data to assess the coldwater and warmwater fishery designated uses for the 2016 Integrated Report. ***Gaps:*** While these data allow the WRD to evaluate fish community data from MDNR-FD status and trend inland lakes, there are no plans to use this methodology to measure biological condition at non-MDNR-FD status and trend inland lakes. In addition, the MDNR-FD data are limited to determining when inland lakes meet the WQS for these uses. All other conclusions will be listed as “needs further assessment” without a metric to assess further. There are no immediate plans to develop a second biological indicator. The WRD looks to the USEPA for guidance as biological indicators are not widely used at this time in inland lakes.

Fish Contaminants

The objectives for fish contaminant monitoring in inland lakes are the same as in other water body types:

1) Determine whether the fish consumption designated use is met and report status in the Integrated Report.
2) Support MDHHS fish consumption advisories.
3) Investigate emerging contaminants as needed.
4) Evaluate temporal trends in fish contaminants.
5) Provide data for the Measures of Success document

Edible Portion Monitoring

The WRD has analyzed fish tissue samples of 30 species from 330 lakes and 93 impoundments since the FCMP began in 1981. Fish are collected from an average of 30 lakes and impoundments each year to measure contaminant levels in edible portions (generally the fillet). Edible portion monitoring is conducted to evaluate the status of contaminant levels in fish statewide and protect human health by supporting MDHHS fish consumption advisories and determining whether the fish consumption designated use is met. Fish are collected both by WRD staff and, to a large extent, MDNR-FD staff during their regular survey work.

The WRD attempts to collect ten samples of top predator species (e.g., walleye, northern pike, largemouth bass, or smallmouth bass) at each site. Depending on the water body, a bottom-feeding species (generally common carp) may be desired. At a minimum, fish fillet samples will be analyzed for mercury. Samples will be analyzed for PCBs, chlorinated pesticides, and a series of other industrial chemicals if it is believed the water body has been contaminated by chlorinated organic contaminants (e.g., proximity to a legacy pollution source). If the concentration of any contaminant exceeds a MDHHS action level, a consumption advisory is issued by the MDHHS and the affected water body is determined to be in nonattainment with WQS by the WRD.

The Measures of Success outcome related to inland lakes, as well as rivers and streams and Michigan's Great Lakes, can be found under the Fish Contaminants heading in the Great Lakes Section.

Whole Fish Trend Monitoring

Of the 22 fixed stations the WRD has established to measure temporal trends in bioaccumulative contaminants in fish tissues, seven are located in inland lakes and four are in river impoundments (Figure 12). Note that fish passage was made possible in 2013 at a previous fifth impoundment site on the Raisin River, and that trend location has been eliminated from future analysis.

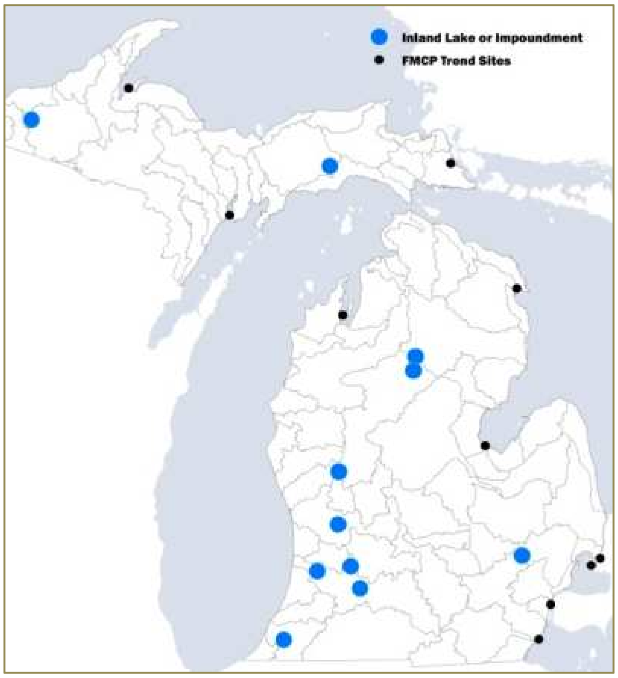


Figure 12. Michigan's 22 fixed trend fish contaminant stations. Locations highlighted in blue are the inland lake and impoundment stations.

Whole fish trend stations have generally been sampled every three to four years since 1990, and results are used to determine temporal trends in mercury, PCBs, DDT, and chlordane. The complete list of parameters measured for this monitoring activity is shown in Table 4.

AIS

The state of Michigan updated its AIS State Management Plan in 2013 through a cooperative effort by the MDEQ, MDNR, Michigan Department of Agriculture and Rural Development (MDARD), and Michigan Department of Transportation. This update called for the establishment of a statewide monitoring and reporting program to be implemented by agency field staff and external partners.

The WRD recently hired a limited-term Aquatic Biology Specialist to work on AIS monitoring issues, including its incorporation into lake and stream monitoring efforts. Until that work is complete, it is not feasible to estimate resource requirements (staff time or funding) needed for this activity. The following recent efforts have begun regarding AIS monitoring in inland lakes.

Snorkeling Pilot Project

The WRD was awarded a GLRI grant by the United States Fish and Wildlife Service to conduct a pilot study to determine the feasibility of using the Wisconsin DNR, "AIS Early Detection Monitoring Standard Operating Procedures," (i.e., snorkeling method to conduct surveillance for a variety of taxa) in Michigan inland lakes. The objectives of this project are:

1) Evaluate the snorkeling method for possible incorporation into the WRD AIS monitoring strategy.
2) Increase collaboration and coordination with local organizations.

Fifteen lakes were surveyed for this project in 2014. Specific details of additional early detection AIS monitoring in inland lakes will be determined after the results of the pilot project are compiled and analyzed. Additional large inland lakes were snorkeled in 2016 to supplement the dataset for this evaluation.

Early Detection

An AIS early detection project for inland lakes was initiated beginning in 2016.

Add-On to Statewide Sampling Efforts

AIS add-on efforts have been included in statewide field sampling efforts since 2014. The procedure includes staff recording AIS observations during the shoreline habitat assessment and identifying AIS found during rake-tosses made at four littoral zone sites in each lake. These efforts have continued and will likely evolve as AIS monitoring objectives are established.

Exotic Plant Watch

There is an AIS component to the Volunteer CLMP. For details see below under Volunteer Monitoring.

Wildlife Contaminants

Bald eagle monitoring provides coverage for the all major water resources in Michigan. However, the description of this program is limited to the Wildlife Contaminants in Great Lakes Section above.

Sediment Chemistry

The WRD partnered with researchers at Michigan State University to perform an inland lake sediment coring project from 1999-2010 using CMI-CWF dollars. This project assessed temporal trends in contaminant inputs into 47 lakes. By dating slices of the sediment core, specific dates were assigned to contaminant concentrations. This project allowed the WRD to assess temporal trends in sediment accumulation rates in the sampled lakes, as well as compare concentrations among lakes. Samples were analyzed for mercury, other trace metals (cadmium, chromium, copper, lead, nickel, and zinc), total PCBs, phosphorus, and organochlorine pesticides. Currently, there are no plans to perform routine sediment chemistry monitoring in inland lakes. ***Gap***: The WRD does not have the capability for this type of monitoring at this time. See the Sediment Chemistry in the Great Lakes Section for details.

NATIONAL MONITORING

The NLA, the NARS inland lake assessment, is designed to help the USEPA and its partners provide regional and national statistically valid estimates of the condition of inland lakes. In 2007 and 2012, the WRD led these efforts and requested additional sites in Michigan to allow for a state-scale assessment. An AIS sampling protocol was included in the 2012 assessment. The next NLA survey will be conducted in 2017.

PROGRAM SUPPORT

Aquatic Nuisance Control

The primary objective of monitoring in the Aquatic Nuisance Control program is to assess the efficacy and selectivity of chemical treatment of aquatic plants. The most extensive monitoring in the Aquatic Nuisance Control program is associated with preparation for, and follow-up on, whole water body treatment with fluridone to target non-native watermilfoil. The monitoring is required by Aquatic Nuisance Control lake management plan guidance and permit conditions and is carried out by licensed chemical applicators or lake management consultants.

Aquatic vegetation monitoring, aquatic herbicide monitoring, and genetic analysis of non-native watermilfoil is occasionally required as a condition of an Aquatic Nuisance Control permit. Program staff conducts minimal monitoring, usually less than ten inland lakes per year, where whole or partial lake vegetation surveys along with Secchi disc measurements are conducted before and/or after treatments. Full aquatic vegetation surveys are also conducted by Aquatic Nuisance Control staff members based on water body nominations submitted during permit application review and in response to stakeholder concerns.

NPDES

Permits for NPDES are issued to municipalities and industries that discharge effluent to the surface waters of Michigan. There are currently about 75 inland lakes – or streams and wetlands in close proximity to inland lakes – with NPDES outfalls. Permit staff in the WRD request targeted monitoring in response to NPDES concerns. Monitoring often occurs within the five-year basin cycle; however, staff can prioritize the work for non-basin cycle years.

Water Withdrawal

The former MDEQ Director, Dan Wyant, established the Water Use Advisory Council in 2013 to provide insight and advice to the MDEQ and other Quality of Life agencies (MDNR and MDARD) regarding Michigan's Water Use Program, which includes water withdrawal. The Water Use Advisory Council established several work groups, including an Inland Lake Adverse Resource Impact work group. The Adverse Resource Impact work group concluded additional information on water levels (average levels as well as ranges of natural variability) and inland lake morphology, which are vulnerable to impacts of direct water withdrawals, was needed. The work group recommended that MiCorps develop protocols for the collection of data by volunteers as one method to obtain needed information. Historically, inland lake water level monitoring has been conducted by the USGS with support from the MDEQ. An extensive amount of historic data has not been catalogued or entered into a database. Future efforts to monitor inland lake levels should involve working with the USGS to take advantage of their expertise and working to utilize the historic data to prioritize future monitoring efforts.

PASS THROUGH GRANTS

See Local Monitoring Grants (non-beach) in the Rivers and Streams section above.

VOLUNTEER MONITORING

> "MiCorps is a network of volunteer monitoring programs in Michigan. It was created through Michigan Executive Order #2003-15 to assist the MDEQ in collecting and sharing water quality data for use in water resources management and protection programs." – MiCorps Web site

The CLMP was established in 1974 and is the second oldest volunteer lake monitoring program in the nation. The program was expanded in 1992 when the MDEQ (then MDNR) formed a cooperative agreement with the Michigan Lake and Stream Association. Together, the CLMP and its sister program, the Volunteer Stream Monitoring Program, form the foundation for MiCorps – see text box. The CLMP is administered by the MDEQ and Michigan Lake and Stream Association and is operated under contract by the Great Lakes Commission, Huron River Watershed Council, and Michigan State University's Department of Fish and Wildlife. Currently, volunteers from about 200 lakes per year are enrolled and trained for the CLMP Program. Secchi disc, phosphorus, and chlorophyll *a* data are collected to determine trophic state from slightly more than 100 lakes per year. Significantly fewer volunteers participate in the temperature and dissolved oxygen profile, aquatic plant identification and mapping, and the exotic plant watch elements of the CLMP.

The objectives of volunteer monitoring are:

1) Develop sustainable volunteer monitoring groups that will learn more about their lake resources.
2) Gather baseline data on lakes and document trends in water quality for individual lakes.
3) Train volunteers to ensure data collected are of high quality and can be used as a screening tool to identify sites that need further evaluation.
4) Identify AIS.

Most volunteer monitoring groups collect data from fixed stations each year. The CLMP includes many lakes, both with and without public access, that are sampled every year for trophic indicators. Some of these lakes have been sampled annually for more than 20 years and the results are used to measure water quality changes from year to year.

The WRD is currently working with Michigan State University to increase enrollment in the Exotic Plant Watch, which was officially added as a component of the CLMP in 2011. The intention of the Exotic Plant Watch is to raise awareness of problematic aquatic invasive plants and facilitate early detection at the local level. Volunteers are trained to identify key species and to use a structured field survey and reporting protocol. The WRD staff participated in a first-of-its-kind "convention" on inland lakes in May 2014 called the Michigan Inland Lakes Partnership.

INLAND LAKE MONITORING SUMMARY AND GAPS

The WRD is making progress to increase inland lake monitoring efforts in Michigan. Resource needs and monitoring gaps related to inland lakes are discussed below under each goal heading and are listed in Table 12:

1) Assess the current status and condition of waters of the state and determine whether WQS are being met

   The WRD assesses water quality status and makes WQS determinations in inland lakes using water chemistry, *E. coli* (beaches), and fish tissue data. The renewed statewide sampling effort, which began in 2014, ensures the WRD will continue to meet this goal of the Monitoring Strategy. The drawback to this program is that lakes are limited to those with public access. Because of difficulties with access and concerns about spending public funds on lakes without public access, the MDEQ does not comprehensively monitor private lakes. Some private lakes are monitored by volunteers, and the use of satellite imagery is being used as a means to assess water clarity and trophic conditions in private (as well as public) lakes. The ***gaps*** associated with this goal for inland lakes are:

   - Inland lake beach monitoring grants are only funded through FY 2018 with CMI-CWF dollars (the last request for proposals is in FY 2017 as these are awarded every other year). Consequently, the WRD's ability to support future monitoring is unknown.

   - The WRD currently does not have a biological indicator in inland lakes. An objective definition of nuisance algae blooms, harmful algal blooms, and nuisance plant growth is needed, along with an assessment method for these evaluations. Staff completed a two-part pilot study to assess harmful algal blooms in 2015: Part 1 - a small number of targeted inland lakes were repeatedly sampled during algae blooms. Water samples were taken using various analytical methods to determine the extent of toxin production by algae during these blooms and to compare the results of the methods; and Part 2 - all 2016 status inland lakes were sampled to understand the statewide extent of harmful algal blooms.

2) Measure spatial and temporal water quality trends

Spatial and/or temporal trends can be evaluated for water chemistry, *E. coli* (beaches), and fish tissue data.

- ***GAP***: The CMI-CWF dollars that support inland lake status and trend laboratory analyses are expected to be fully expended after 2018. Consequently, the WRD's ability to support future monitoring is unknown.

3) Evaluate the effectiveness of water quality restoration and protection programs

The first three nutrient TMDLs written were large-scale, including all, or a large portion, of the watersheds. These inland lakes (Lake Allegan, Lake Macatawa, and Ford and Belleville Lakes) are monitored biennially. Remaining lakes with TMDLs are monitored as resources allow and when there is an expected change to document.

The WRD support MDNR-FD status and trend inland lakes program by funding water chemistry monitoring and partnering to reduce efforts; inland lake beach grants support local community health departments; however these grants will no long be available after FY 2017 unless a new funding source replaces CMI-CWF; edible portion fish tissue monitoring supports the MDHHS in their fish consumption advisory.

4) Identify new and emerging water quality problems

Note that AIS monitoring is not listed as a gap. Because the program is in development, it is difficult to define where it belongs regarding the four goals of the Strategy. AIS will likely fall in the status goal, but whether for established or emerging species or both has not been determined.

Table 12. Summary of monitoring efforts, water quality indicators, and gaps for designated use determinations in Michigan's Inland Lakes.

Designated Use	WRD efforts to make WQS determinations
Agriculture, Navigation, Industrial Water Supply	These uses are assumed to be supported unless there is site-specific information indicating otherwise.
Warmwater Fishery	All inland lake monitoring includes temperature/dissolved oxygen profiles from at least one location. • Dissolved oxygen (R 323.1065) • Temperature (R 323.1069, R 323.1072, R 323.1073) Secondary data: Starting in the 2016 Integrated Report, MDNR status and trend lake data are used to assess this use. ***Gap***: The WRD currently does not have biological condition methods to assess the fish community in inland lakes for this use.
OIALW (includes pH, Ammonia)	Inland lake monitoring that includes water chemistry sampling. • Toxic substances, typically low-level total mercury in water (R 323.1057) • Plant nutrients (R 323.1060) • Physical characteristics (R 323.1050) (e.g., turbidity, suspended solids, oil films) • Carlson's Trophic State Index in conjunction with aquatic macrophyte surveys ***Gap***: The WRD does not currently use biological indicators to assess this use in inland lakes other than the plant nutrient narrative criteria in R 323.1060.
PBC and TBC	Primarily this includes inland lake beach *E. coli* monitoring performed by local health departments with pass-through CMI grants administered by the WRD. • Microorganisms (R 323.1062)
Fish Consumption	Edible fish portion monitoring is performed at targeted monitoring locations each year.
Coldwater Fishery (includes pH, Ammonia)	All inland lake monitoring includes temperature/dissolved oxygen profiles from at least one location. • Dissolved oxygen (R 323.1065) • Temperature (R 323.1069, R 323.1072) Secondary data: Starting in the 2016 Integrated Report, the MDNR status and trend lake data are used to assess this use. ***Gap***: The WRD currently does not have biological condition methods to assess the fish community in inland lakes for this use.
Public Water Supply	Not applicable.

WETLANDS

Wetland in Mackinaw County
– photo courtesy of Anne Garwood

ROUTINE MONITORING

The MDEQ has completed a comprehensive wetlands monitoring and assessment strategy (MDEQ, 2015a), which is guided by the four surface water monitoring goals outlined in Section 1 of this document. The primary focus of Michigan's wetland monitoring effort is to evaluate the success of the state in protecting, managing, and restoring Michigan's wetlands such that they will continue to provide the public benefits defined by the legislature in Part 303, Wetlands Protection, of the NREPA. Assessment and monitoring of Michigan's wetland resources provides information to address diverse program issues at a variety of scales, from the status and trends of statewide wetland acreage to the detailed evaluation of individual wetland sites. The evaluation of individual wetlands is also a component of Michigan's regulatory program under Part 303 and Section 404 of the Clean Water Act, which requires annual reporting on statewide regulatory impacts. Land use planners are also increasingly considering wetland functions, wetland quality, and restoration opportunities in watershed scale planning and in local NPS control programs.

The following is an overview of the *State of Michigan Wetland Monitoring and Assessment Strategy* (MDEQ, 2015a), which was written as a supplement to the Surface Water Monitoring Strategy and its updates (including this document). To avoid possible inconsistencies that may result from future revisions, details are not included here. Please see the WRD wetland monitoring page for the most recent *State of Michigan Wetland Monitoring and Assessment Strategy* in its entirety.

The USEPA has a developed a 3-tiered framework, as shown in Figure 13, for the assessment and monitoring of wetland resources that has been adopted by the MDEQ's wetlands program (USEPA, 2006). With these 3 tiers are 8 specific objectives that follow the broad four goals of this Strategy and are consistent with the federal goal of determining whether national no net loss/net gain targets for wetlands are being achieved.

3-Tiered Technical Approach	Products/Applications
Level 1 – Landscape Assessment Use GIS and remote sensing to gain a landscape view of watershed and wetland condition. Typical assessment indicators include wetland coverage (NWI), land use, and land cover.	• Status and Trends • Targeting restoration and monitoring • Landscape condition assessment • Integrated Reporting CWA 305(b)/303(d)
Level 2 – Rapid Wetland Assessment Evaluate the general condition of individual wetlands using relatives simple field indicators. Assessment is often based on the characterization of stressors known to limit wetland functions, e.g. road crossings, tile drainage, ditching.	• 401/404 permit decisions • Integrated Reporting • Watershed Planning • Implementation monitoring of restoration projects
Level 3 – Intensive Site Assessment Produced quantitative data with known certainty on wetland condition within an assessment area, used to refine rapid wetland assessment methods and diagnose the causes of wetland degradation. Assessment is typically accomplished using IBI's or HGM.	• WQS development, including use designation • Integrated Reporting • Compensatory mitigation performance standards • Verify Levels 1 and 2 methods

Figure 13. Tiered Approach to wetland monitoring – *taken from the Wetland Monitoring Strategy, 2015.*

Level 1 - Landscape Assessment

Objective 1: Complete an inventory of Michigan's wetland resources that provides both basic resource information and a baseline for evaluating gains and losses over time.

Objective 2: In order to support state and national no net loss and net gain goals for wetlands, cooperate in updating of National Wetlands Inventory maps for use in status and trends reporting.

Objective 3: Assess the effectiveness of Michigan's state-administered Section 404 permit program by tracking authorized wetland impacts and mitigation for those impacts, as well as documented unauthorized impacts and restoration measures.

Objective 4: Apply Landscape Level wetland assessment methods to support the protection, management, and restoration of wetlands on a watershed-scale.

Level 2 - Rapid Wetland Assessment

Objective 5: Evaluate individual wetland sites using the MiRAM to quickly assess wetland functions and values regardless of ecological type.

Level 3 - Intensive Site Assessment

Objective 6: Use full-scale biological assessment of wetlands for resource management purposes. Develop and document wetland Indexes of Biotic Integrity and related methods.

Objective 7: In cooperation with other public and private agencies and organizations, provide for the evaluation of Michigan's most outstanding wetland resources, especially Great Lakes coastal wetlands, by supporting the long-term monitoring of coastal wetlands through the Great Lakes Coastal Wetlands Consortium and similar cooperative efforts.

Objective 8: Assess statewide wetland quality by establishing a routine wetland monitoring program that parallels other basin-wide water quality monitoring, including the NWCA.

Michigan's Wetland Monitoring and Assessment Strategy can be found at: https://www.michigan.gov/-/media/Project/Websites/egle/Documents/Programs/WRD/Wetlands/wetland-monitoring-assessment-strategy.pdf.

NATIONAL ASSESSMENT

The NWCA, the NARS wetland assessment, is designed to help the USEPA and its partners provide regional and national statistically valid estimates of the condition of the nation's wetlands. In 2011, the WRD contribution in the NWCA was limited to the participation of a soil scientist on the wetland sites in Michigan. The WRD monitored all 17 wetland sites assigned to Michigan (plus two revisits) in 2016 and is performing additional sites to allow for a state-scale assessment.

WETLAND MONITORING SUMMARY AND GAPS

The WRD is making progress to increase wetland monitoring efforts in Michigan. Resource needs and monitoring gaps related to wetlands are discussed in Michigan's Wetland Monitoring and Assessment Strategy.

To date, net gain or loss of wetlands is a primary indicator of the overall condition of the state's wetland resources. State and federal no net loss/net gain goals address not only the quantity of wetland resources but the quality of those resources. However, goals for wetland quality are not fully defined at this time at the state, regional, or national level. The USEPA, Region 5, Water Division and Great Lakes National Program Office; the MDEQ; and resource agencies from the other Region 5 states have worked together to develop a set of shared regional water *goals, milestones*, and associated environmental *indicators*. On December 11, 2001, each of these organizations signed a Joint Commitment to Achieve Shared Water Goals, which documents our commitment to the goals.

Site-specific indicators of wetland quality developed include Indexes of Biotic Integrity, the MiRAM, and the Great Lakes Coastal Wetlands Indicators. Great Lakes Coastal Wetland monitoring incorporates the suite of indicators recommended by the Great Lakes Coastal Wetlands Consortium in the Great Lakes Coastal Wetland Monitoring Plan (2008) to contribute to this long-term, basin-wide initiative.

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Appendix A.

Summary of gaps identified in *Michigan Surface Water Monitoring Strategy Update 2016*.

Medium/ Element:	Gap	Page
General	Update *Surface Water Quality Assurance Manual*	22
	Lack of public access to data: non-beach pathogen monitoring, water quality monitoring reports, sediment data for remedial investigations, inland lake field data, inland lake sediment data, biological community data, data from local water quality monitoring grants	28
	Equipment needs	38
	Climate change monitoring	65
Great Lakes	Lack of biological indicators for aquatic life use designations	17, 56
	DEQ involvement in CSMI limited to Lake Michigan	53
	Water chemistry monitoring is limited to connecting channels, Saginaw and Grand Traverse Bays	55
	Likely cuts in funding for Great Lakes beach monitoring	55
	Likely cuts in funding for Great Lakes water chemistry and fish tissue	56
	Likely cuts in funding for Great Lakes Areas of Concern support	56
	Lack of a methodology for assessing coldwater fishery use designation	56
	Limited monitoring to assess Public Water Supply use designation	55, 57
Rivers and Streams	Compare P-51 to NRSA for biological condition	17
	Re-assess P-51 reference sites	17
	Consider sampling fish at more P-51 sites	18, 62, 69
	Lack of a methodology (indicator) for evaluating fish community data in nonwadeable rivers to make impairment determinations	18, 71
	Lack of a methodology for monitoring headwater streams	18, 63
	Limited monitoring for Total Body Contact use attainment (10%)	70
	P-22 has not been evaluated for use as a trend procedure	70
	Support to Heidelberg University is limited and funding source (CMI-CWF) will be gone soon	70
	Limited monitoring to assess Public Water Supply use designation	71
Inland Lakes	Lack of biological monitoring and no IBIs available for inland lakes	18, 74, 79
	MDNR fish data limited to MDNR-FD status and trend lakes; data are limited to determining whether lake meets WQS, and not to make impairment determination	74
	No available funding for inland lake beach monitoring once CMI-CWF funding runs out	79
	No available funding for inland lake status and trend monitoring once CMI-CWF funding runs out	80