Enclosure 1

Michigan Statewide Mercury Total Maximum Daily Load

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List of Acronyms

ALA	Anthropogenic Load Allocation
ANPSL	Anthropogenic Nonpoint Source Load
AOC	Area of Concern
AQD	Air Quality Division
AUID	Assessment Unit Identification
BAF	Bioaccumulation Factor
CFR	Code of Federal Regulations
CMAQ	Community Multi-scale Air Quality Model
EAF	Electric Arc Furnace
EIF	Electric Induction Furnace
ECOS	Environmental Council of States
EDU	Ecological Drainage Unit
FCMP	Fish Contaminant Monitoring Program
GLRI	Great Lakes Restoration Initiative
HUC	Hydrologic Unit Code
km^2	Square Kilometers
LC	Loading Capacity
LA	Load Allocation
Lbs	Pounds
LCA	Level Currently Achievable
MATS	Mercury and Air Toxics Standards
MCGI	Michigan Center for Geographic Information
MCM	Mercury Cycling Model
MDEQ	Michigan Department of Environmental Quality
MDHHS	Michigan Department of Health and Human Services
MDV	Multiple Discharge Variance
mg/kg	Milligrams per kilogram
MiSWIM	Michigan Surface Water Information Management System
MOS	Margin of Safety
MPCA	Minnesota Pollution Control Agency
NEIWPCC	New England Interstate Water Pollution Control Commission
NHD	National Hydrography Dataset
Ng/L	Nanograms per Liter
NLA	Natural Load Allocation
NNPSL	Natural Nonpoint Source Load
NP24	Northern Pike, 24 inches
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source
NPSL	Nonpoint Source Load
PMP	Pollutant Minimization Program
PPM	Parts Per Million
PSL	Point Source Load
REMSAD	Regional Modeling System for Aerosols and Deposition
RF	Reduction Factor
TF	Target Fish
TMDL	Total Maximum Daily Load
TSL	Total Source Load
U of M	University of Michigan
µg/g	Micrograms per Gram

µg/L	Micrograms per Liter
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WCMP	Water Chemistry Monitoring Program
WLA	Waste Load Allocation
WQS	Water Quality Standards
ww	Wet Weight
WWTP	Wastewater Treatment Plant

EXECUTIVE SUMMARY

Mercury is a naturally-occurring metal that is prevalent throughout the global environment. The well-known neurotoxic properties of mercury make it dangerous, at high exposure levels, for both humans and wildlife, especially the young. Human exposure through consumption of fish is the principal public health concern with mercury in the environment. Mercury emitted to the atmosphere can be transported short and long distances from its source before being deposited to land and water. The widespread loading of mercury into the Great Lakes region caused mercury-related fish consumption advisories in all of the 8 Great Lakes states. This Total Maximum Daily Load (TMDL) addresses inland water bodies in Michigan. Of the inland water body segments assessed for mercury in Michigan, 743 are impaired due to mercury. Of these water body segments, 462 are impaired due to mercury in fish tissue, 260 are impaired due to mercury in the water column, and 21 are impaired based on mercury in both fish tissue and the water column (Figure ES-1). While the Great Lakes and connecting channels (i.e., Lake St. Clair, St. Clair River, St. Marys River, Detroit River, and the Keweenaw Waterway) will benefit from the atmospheric reductions called for in this TMDL, these water bodies will be considered under a separate, future TMDL (date to be determined), focused on the Great Lakes. The level of pollutant reduction required to achieve the Water Quality Standards (WQS) for these water bodies will be different than for inland waters, due to different atmospheric deposition rates and much longer response times. Appendix A lists specific water body segments covered by this TMDL.

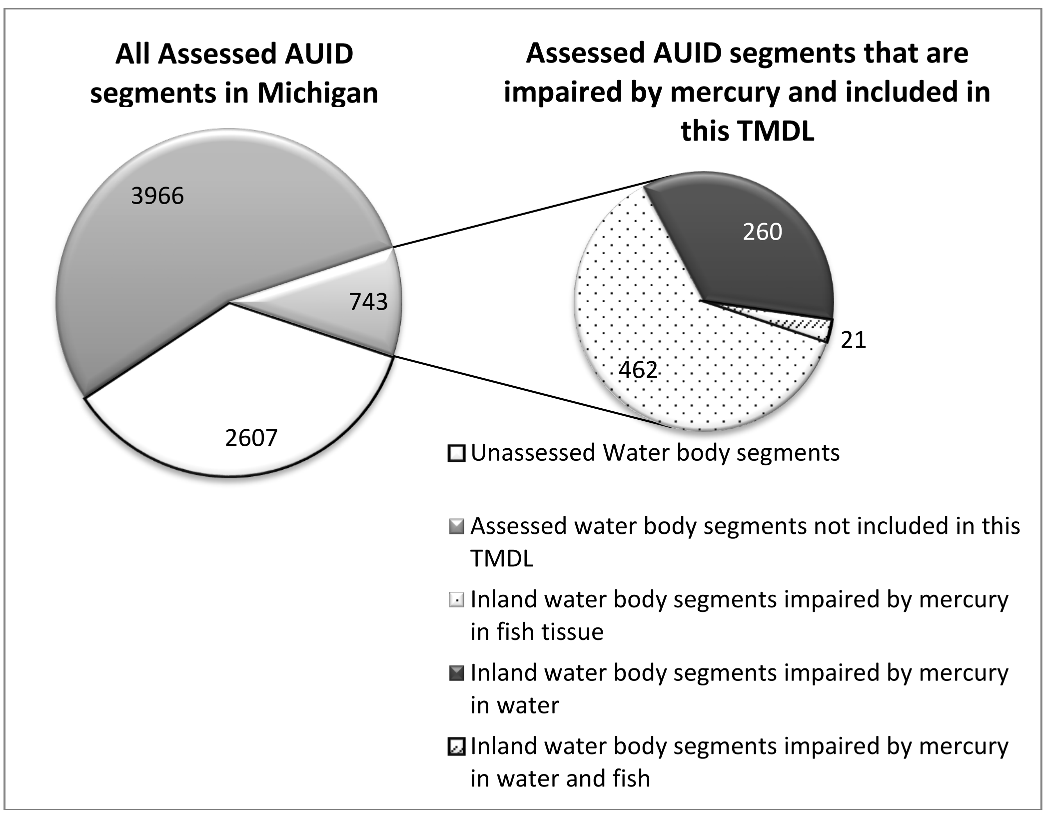


Figure ES-1. Assessed and Mercury-Impaired Water Body Segments in Michigan.
Source: Michigan Department of Environmental Quality (MDEQ), 2012a.

In Michigan, the majority of mercury pollution in water bodies is a result of atmospheric deposition. A statewide TMDL has been developed to address mercury impairment in Michigan inland water bodies. Based on a target fish tissue mercury concentration of 0.35 milligrams per kilogram (mg/kg), the TMDL establishes a goal for reducing atmospheric mercury loading relative to the 2001 baseline loading.

Atmospheric mercury deposition in Michigan comes from local, regional, national, and global sources that are both anthropogenic and natural in origin. Atmospheric mercury deposition originating from sources within and outside of Michigan was estimated for the baseline year of 2001 using a United States Environmental Protection Agency (USEPA) model. Based on the assumption that fish mercury concentrations will respond proportionally to reductions in atmospheric mercury loadings, a TMDL and an associated load reduction goal were developed to meet the target fish tissue concentration of 0.35 mg/kg. Reductions are necessary from mercury sources within Michigan, other U.S. states, and global sources; however, this TMDL only addresses reductions from Michigan sources. Anthropogenic atmospheric sources of mercury from Michigan must be reduced by 81% from 2001 levels to meet this goal (Table ES-1). Progress in achieving this goal in Michigan will be tracked using air emissions from the year 2002 as the baseline, since a complete emissions inventory for the baseline year 2001 is not available. Mercury fish tissue concentrations will also continue to be monitored to determine future progress.

Table ES-1. Summary of TMDL Components.

TMDL Components	Units	Statewide
Target Level and Reduction Factor		
Target Fish Mercury Concentration (Fish Tissue Residue Value)	mg/kg	0.35
Current Mercury Concentration for Standard Length Northern Pike	mg/kg	1.012
Reduction Factor (1.012 mg/kg – 0.35 mg/kg/1.012 mg/kg)	65%	
Mercury Load for Baseline Year 2001		
Point Source Load (39 kg/yr÷365)	kg/day	0.11
Nonpoint Source Load (REMSAD Model) (2,734 kg/yr÷365)	kg/day	7.49
Total Source Load	kg/day	7.6
Final TMDL		
Margin of Safety	Implicit	
Waste Load Allocation (6 kg/yr÷365)	kg/day	0.016
Load Allocation (Includes Natural and Anthropogenic Sources (953 kg/yr÷365)	kg/day	2.61
Mercury Load Allocation for In-State and Out-of-State Deposition Sources		
In-State Contribution to Load Allocation (40 kg/yr÷365)	kg/day	0.11
Out-of-State Contribution to Load Allocation (913 kg/yr÷365)	kg/day	2.5
Necessary Reduction from Anthropogenic Emission Sources (40 kg÷213 kg) ~ 19% (100% -19% = 81%)		81%

Note: Numbers may not sum exactly due to rounding.

1 INTRODUCTION

Section 303(d) of the federal Clean Water Act and the USEPA's Water Quality Planning and Management Regulations (Title 40 of the Code of Federal Regulations [CFR], Part 130, Water Quality Planning and Management) require states to develop TMDLs for all Category 5[1] water bodies that are not meeting the WQS for a specific pollutant. These water bodies are included on a state's Section 303(d) list. The TMDL process establishes the allowable loadings of a pollutant to a water body based on the relationship between pollution sources and water quality conditions of a water body. This allowable loading represents the maximum quantity of a pollutant that the water body can receive without exceeding the WQS. The TMDL process provides states with the basis for establishing water quality-based controls, which define the pollutant reductions necessary for a water body to attain the WQS (USEPA, 1991).

Sections 303(d), 305(b), and 314 of the 2012 Michigan Integrated Report (MDEQ[2], 2012a) identified 6,712 miles of rivers and streams and 246,271 acres of inland lakes and reservoirs as not supporting their designated uses due to high concentrations of mercury in fish tissue. In addition, 7,068 miles of rivers and streams, and 211 acres of lakes and reservoirs are not supporting their designated use due to mercury in the water column (MDEQ, 2012a).

This mercury TMDL covers inland water bodies in the state of Michigan primarily impacted by atmospheric deposition of mercury. These water bodies are described further in Section 2 and Appendix A. Once approved, this TMDL document will be routinely revised only to add additional impaired water bodies. Proposed impaired water bodies that are identified by future monitoring will be added via Appendix A to the TMDL released with the MDEQ's biennial submittal of the Integrated Report (hereafter referred to as the Statewide Mercury TMDL Appendix A). Minimum water quality monitoring data requirements for determining if a water body is impaired by a pollutant are described in the assessment methodology section of the MDEQ's Integrated Report. This assessment methodology is updated with each biennial submittal. Beginning with the 2018 version of the Integrated Report, the Statewide Mercury TMDL Appendix A will clearly and concisely present proposed new impaired water bodies to the public and the USEPA, along with a cumulative list of all water bodies that are included in this TMDL, and water bodies that have been restored and are no longer impaired (Integrated Report assessment category 2). Proposed impaired water bodies due to mercury will be placed in the "Impaired, TMDL completed" Integrated Report assessment category (category 4a). Once the USEPA approves the Statewide Mercury TMDL Appendix A, the newly proposed water bodies will be part of this statewide TMDL. It is the MDEQ's intent that no new water bodies will be added to the Integrated Report assessment category "Impaired-TMDL needed" (category 5) for mercury-impaired waters.

Water bodies that have been restored to meet the appropriate designated uses, and are part of this statewide TMDL, will be listed as fully attaining (category 2) in the next applicable Section 305(b) list. To be considered fully restored, data must fall below the exceedance thresholds described in the Integrated Report assessment methodology as demonstrated by a study that is comparable in scope to the study that was used to list it as nonattaining. Data

[1] Category 5 means available data and/or information indicate that at least one designated use is not being supported or is threatened, and a TMDL is needed.
[2] For a short period of time (October 2009-March 2011) the MDEQ was reorganized and known as the Michigan Department of Natural Resources and Environment. For consistency, MDEQ is used throughout this document when referencing the agency.

submitted by outside agencies is acceptable for determining designated use attainment, but must meet quality assurance/quality control requirements of the MDEQ.

The Integrated Report is available on the MDEQ Web site and the 30-day public notice for the biennial submittal shall serve as the required public notice for the proposed addition of impaired water bodies in the TMDL Appendix A.

If the Michigan mercury WQS changes in the future, this TMDL will be revised to reflect changes in the WQS.

This document describes the statewide approach that Michigan has taken to develop a TMDL for mercury. The report covers each step of the TMDL process and is organized as follows:

Section 2: Background
Section 3: Applicable WQS and Numeric Targets
Section 4: Modeling Approach
Section 5: Source Assessment
Section 6: TMDL Development
Section 7: Reasonable Assurance and Implementation
Section 8: Post-TMDL Monitoring

2 BACKGROUND

This section provides background information for mercury TMDL development. It is divided into the following components:

- Problem Statement
- Data Collection and Assessment of Water Quality
- Scope of Water Bodies Considered Under this TMDL

2.1 PROBLEM STATEMENT

Mercury is a metal that occurs naturally in the environment in the mineral form of cinnabar or metacinnabar (HgS). About 90% of the mercury produced in the U.S. between 1850 and 1980 was mined from the mountains of central-western California (Davis et al., 2003), and most of this mercury was used to assist with the extraction of gold from California mines in the Sierra Nevada mountains.

Over time, the largest use of mercury in the U.S. has been for batteries, followed by the chlor-alkali process in which liquid mercury acts as a cathode to aide in the electrolysis of salt water (Sznopek and Goonan, 2000). Other major uses of mercury in the U.S. include paint, lighting, switches, instruments, dental and other laboratory uses, and other industrial applications (Sznopek and Goonan, 2000). Local and global anthropogenic activities such as mining, coal combustion, and industrial uses have made mercury more readily available in the environment than in the preindustrial period, generally in the form of elemental mercury (Hg^0) or ionic (Hg^{2+}) mercury species.

Although health impacts of exposure to high levels of elemental mercury have been documented (Gochfeld, 2003), the primary environmental concern at lower ambient concentrations is with methylmercury, the most bioavailable and bioaccumulative form of mercury. Methylmercury is produced through the addition of a methyl group to Hg^{2+}, a process referred to as methylation (Figure 1). Methylation is performed primarily by sulfate-reducing bacteria (Compeau and Bartha, 1985; Regnell et al., 1996; Gilmour et al., 1998), which are found at zones of transition from oxic (i.e., containing oxygen) to anoxic (i.e., absence of oxygen) conditions in the water column or sediment (Bloom et al., 1999; Gilmour et al., 1998; Devereux et al., 1996; Slotton et al., 1995; Watras et al., 1994; Choi and Bartha, 1993). Net methylmercury production (i.e., methylmercury production in excess of degradation) is the most important environmental process that leads to food web accumulation.

The strong reactivity of methylmercury with sulfhydryl groups of proteins in the body is responsible for its high degree of bioaccumulation in fish and other types of organisms (Beckvar et al., 1996). Phytoplankton can concentrate dissolved methylmercury in the water column approximately 100,000 times greater than water column concentrations, making this a critical step in the bioaccumulation process (Watras et al., 1994). After this initial step, methylmercury concentrations increase approximately three-fold with each additional step in the food chain (Watras et al., 1994), in a process known as biomagnification (Figure 1). In this process, consumers retain and further concentrate much of the methylmercury of their prey, and subsequently pass the higher levels of mercury on to the next trophic level. Species at high trophic levels in the aquatic food web, such as predatory fish, attain concentrations that can be up to a million times higher than the concentration in water.

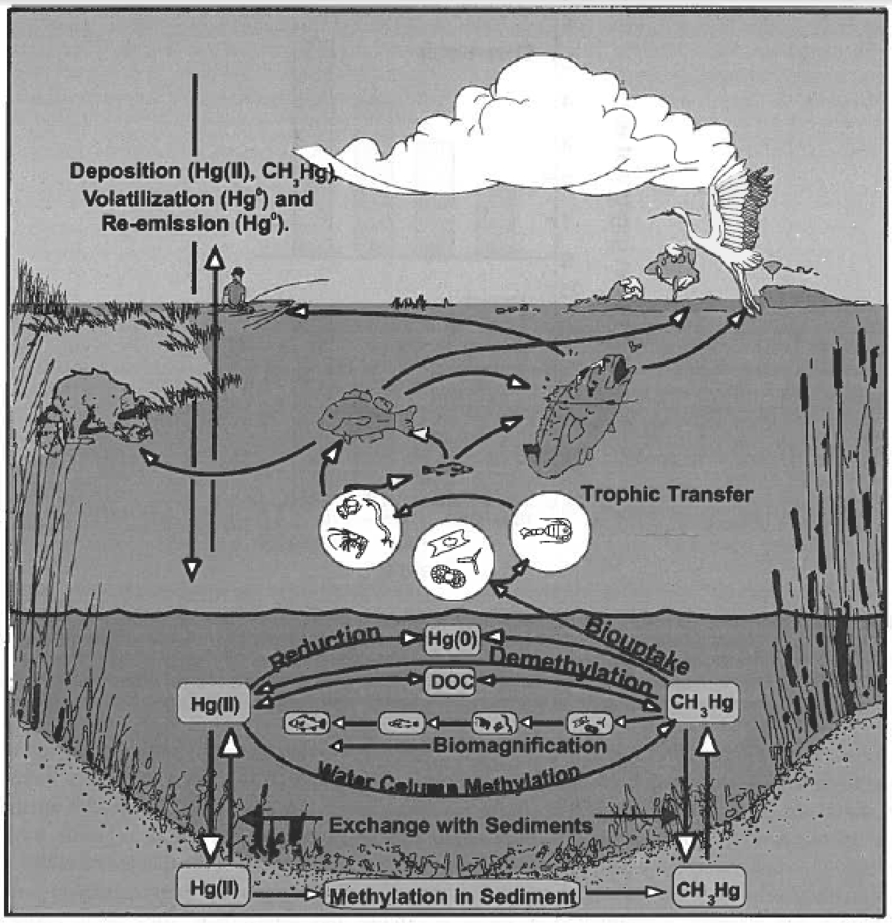


Figure 1. Mercury Processes in the Environment.
Methylation in the sediment leads to uptake through the food chain. Biomagnification results in higher trophic levels accumulating much higher concentrations of mercury. (Source: Wiener et al., 2003)

There are various exposure routes to mercury, including groundwater, air, sediment, and water, but the primary route of methylmercury exposure in humans in the U.S. is via fish consumption (Figure 2). When ingested, methylmercury in fish tissue is almost completely absorbed from the gastrointestinal tract. Once absorbed, methylmercury is distributed throughout the body and is concentrated in the brain, liver, kidneys, peripheral nerves, and bone marrow. For pregnant women, methylmercury also concentrates in the placenta, fetus, and particularly the fetal brain (Berlin et al., 2007). The ability of methylmercury to cross the placenta as well as the blood-brain barrier allows methylmercury to accumulate in the brain and fetus, which are known to be especially sensitive to the toxic effects of this chemical (Klasing and Brodberg, 2008).

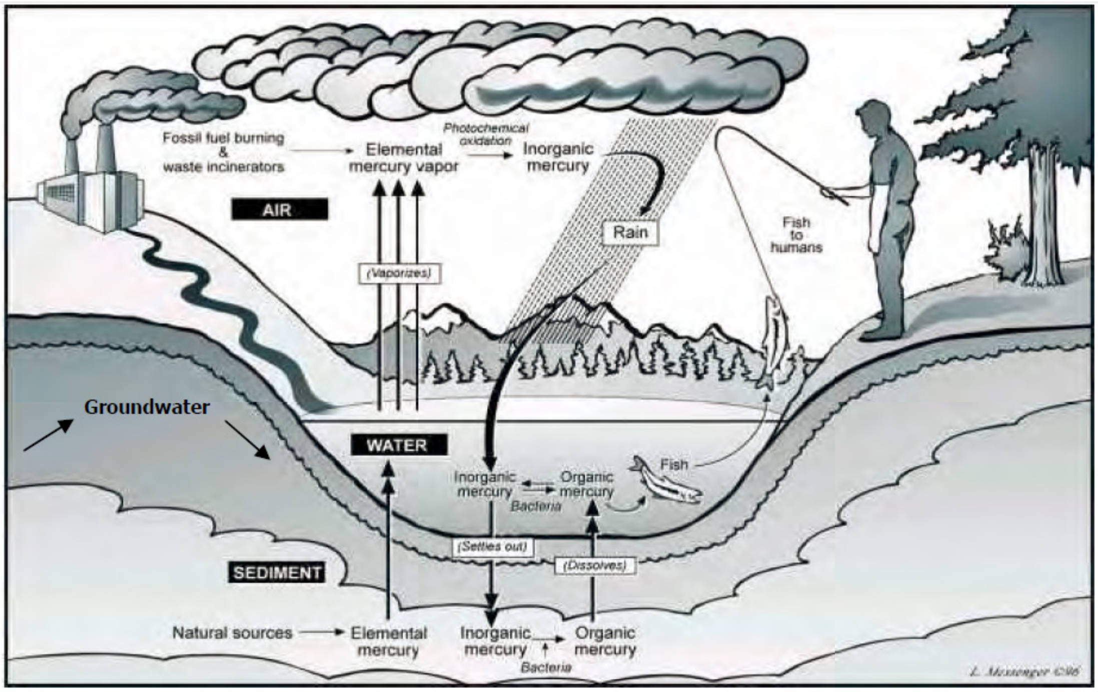


Figure 2. The Mercury Cycle. Source: MDEQ, 2008a.

Fish, birds, and other animals are sensitive to mercury in the environment. Consumption of fish by other animals such as mink, otter, and fish eating birds, is the primary mechanism for methylmercury exposure; therefore, aquatic species are particularly vulnerable to mercury contamination. Toxic effects have been documented in animals that consume fish with a mercury concentration starting at 0.3 to 0.7 micrograms per gram (µg/g) wet weight (ww) in the whole body of fish (Wiener et al., 2007). Depew et al. (2012) proposed a threshold of 0.1 µg/g ww methylmercury in prey fish as the lowest benchmark for adverse behavioral impacts in adult loons. They also proposed benchmarks of 0.18 and 0.4 µg/g ww in prey fish for significant reproductive impairment and for reproductive failure in wild adult loons, respectively. Thresholds for adverse effects in loon tissues and prey were published, and included 3.0 µg/g (ww) in adult blood, 40.0 µg/g (ww) in adult feathers, 1.3 µg/g (ww) in eggs, and 0.16 µg/g (ww) in prey fish (Evers et al., 2008a).

A collection of blood, feathers, and eggs of Yellow-billed Loons in Alaska, between 2002-2012, found mercury concentrations that ranged from 0.08 to 1.45 µg/g ww in blood, 3.0 to 24.9 µg/g fresh weight in flight feathers, and 0.21 to 1.23 µg/g ww in eggs (Evers et al., 2014). Mercury concentrations found in blood, feathers, and egg tissue of Yellow-billed Loons indicate that some individuals across North America are at risk of lowered reproductive success from mercury exposure (Evers et al., 2014). Based on Common Loon studies, significant risk of reduced reproductive success generally occurs when adult mercury concentrations exceed 2.0 µg/g ww in blood, 20.0 µg/g fresh weight in flight feathers, and 1.0 µg/g ww in eggs (Evers et al., 2014). Due to the wide-ranging use and release of mercury, and consequent impacts on humans and wildlife, the MDEQ convened the Mercury Strategy Work Group in 2006. The Mercury Strategy Work Group produced a Mercury Strategy for Michigan that included an inventory of releases in Michigan for 2002 (Appendix G of MDEQ, 2008a). A total of 8,440 pounds (lbs) (3,828 kg) of mercury were estimated to be released into the environment through multiple pathways (e.g., air, land, and water) in 2002. The report details emissions for several source categories including fuel combustion, industrial sources, incineration, area sources, and mobile sources. In 2002, the largest industrial source of mercury emissions in Michigan was coal-fired power plants (MDEQ, 2008a).

To reduce future releases, the Mercury Strategy Work Group set an overall goal of eliminating anthropogenic use and release of mercury in the state. In addition, two interim goals were established. These goals are: (1) by 2010, to reduce mercury use and release to the environment by 50%; and (2) by 2015, to reduce mercury use and release to the environment by 90% (MDEQ, 2008a). A 2005 mercury air emissions inventory demonstrated an approximate 10% reduction in emissions relative to 2002. A 2011 mercury emissions inventory estimated an approximate 20% emission reduction from the 2002 baseline.

2.1.1 TMDL Development Process

Reducing human and wildlife exposure to mercury is a priority in Michigan (MDEQ, 2008a). The Michigan Department of Health and Human Services (MDHHS) continues to issue general fish consumption guidelines for all inland lakes in Michigan, and specific recommendations for Lakes Huron, Michigan, and Superior, and several hundred miles of rivers and streams due to mercury concentrations in fish tissue.[3] Because of the widespread impairment of Michigan's waters due to mercury, this statewide TMDL has been developed for inland waters primarily impacted by atmospheric deposition of mercury. This TMDL describes the pollutant reductions necessary to attain the WQS.

Historically, considerations used to prioritize water bodies for TMDL development in Michigan include the existing TMDL schedule (i.e., the number of TMDLs currently scheduled for each year), Michigan's 5-year rotating watershed monitoring cycle (Figure 3), available staff and monetary resources to complete TMDLs, quantity and quality of data with supporting information on the pollutant causing the impairment, complexity of the problem as well as severity of the pollution, and the USEPA's recommendation to develop TMDLs within 13 years of listing (MDEQ, 2012a). In December 2013, the USEPA announced the "Long-Term Vision for Assessment, Restoration, and Protection under the Clean Water Act Section 303(d) Program" (Vision). As part of the Vision, individual states were required to develop a systematic approach to prioritize waters for TMDL development, restoration, and protection. The MDEQ submitted a prioritization framework to the USEPA in April 2015, which identified specific TMDLs to be developed between 2016-2022. This prioritization framework included this statewide mercury TMDL.

Great Lakes and connecting channels will be considered separately from this statewide inland mercury TMDL. A Great Lakes mercury TMDL will be developed in the future at a date to be determined.

[3] MDHHS Eat Safe Fish (Michigan.gov/eatsafefish.)

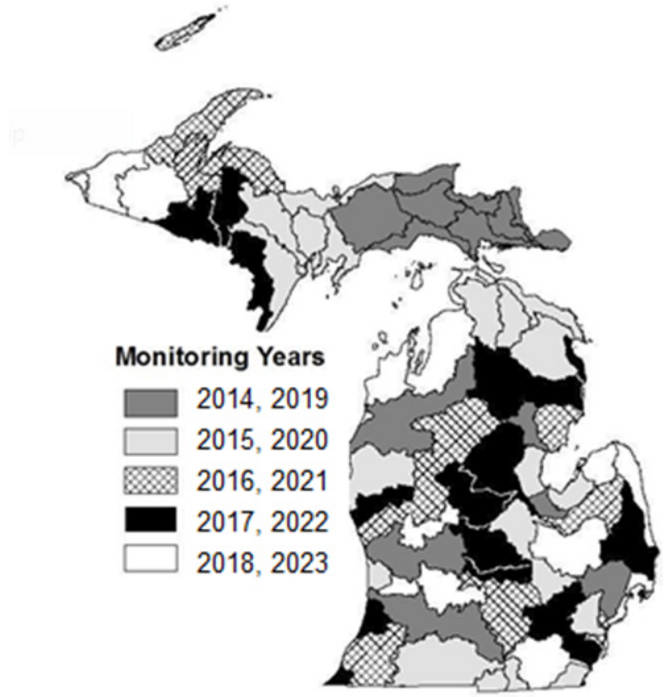


Figure 3. The MDEQ's 5-year Rotating Watershed Monitoring Cycle.

2.1.2 Recent Mercury Trends

The Binational Toxics Strategy was a joint U.S.-Canada effort to reduce pollution from toxic contaminants (it has since been replaced by the Great Lakes Restoration Initiative [GLRI]). In a 2006 progress report, the USEPA reported that total U.S. emissions of mercury decreased by 47% between 1990 and 2002. Emission reductions may have been even larger since gold mining and electric arc furnaces were not included in the 1990 inventory. The biggest reductions in mercury emissions came from medical waste incinerators and municipal waste combustors (USEPA, 2006). A more recent report documented a 75% reduction in U.S. mercury emissions between 1990 and 2008 (Quicksilver Caucus, 2012).

Air concentrations of mercury from event precipitation samples were measured over 10 years by the University of Michigan (U of M), Air Quality Laboratory (2009), in collaboration with the MDEQ at 3 sites (Figure 4). There is a clear decreasing spatial trend of wet mercury deposition from south (Dexter, shown on the left for each year) to north (Eagle Harbor, shown on the right for each year), but no statistically significant statewide trend was observed over this time period (MDEQ, 2008a). The MDEQ began wet deposition monitoring again using USEPA funding at both Pellston and Dexter in 2014 for weekly composite wet deposition samples. Data from these sites is available at *(The link provided was broken and has been removed.)*. Evers et al. (2011) also reported no evidence of appreciable decline in wet deposition in the Great Lakes and Canada between 2002 and 2008. Data collected in Michigan and elsewhere has demonstrated elevated atmospheric mercury deposition in urban locations (Landis et al., 2002; Keeler et al., 2006; Liu et al., 2010). In Michigan, wet deposition was 2-fold higher in southeast Michigan, as compared to the Upper Peninsula (Keeler and Dvonch, 2005). These data identify additional opportunities for further mercury reductions from anthropogenic sources.

Precipitation rates continue to increase within the Great Lakes Basin, which can impact identification of temporal and spatial trends of atmospheric mercury deposition (Risch et al., 2012). Statistically significant reductions in weekly mercury wet deposition at Michigan mercury deposition network locations from 2002-2010 were found by Risch et al. (2014). Additionally, a Great Lakes region-wide decrease of approximately 20% of sediment mercury flux suggests that controls on the local and regional atmospheric mercury emissions have been effective in decreasing the atmospheric mercury loadings to inland lakes and Lake Superior, suggesting a "cause and effect" relationship between local/regional mercury emission controls (Drevnick et al., 2012).

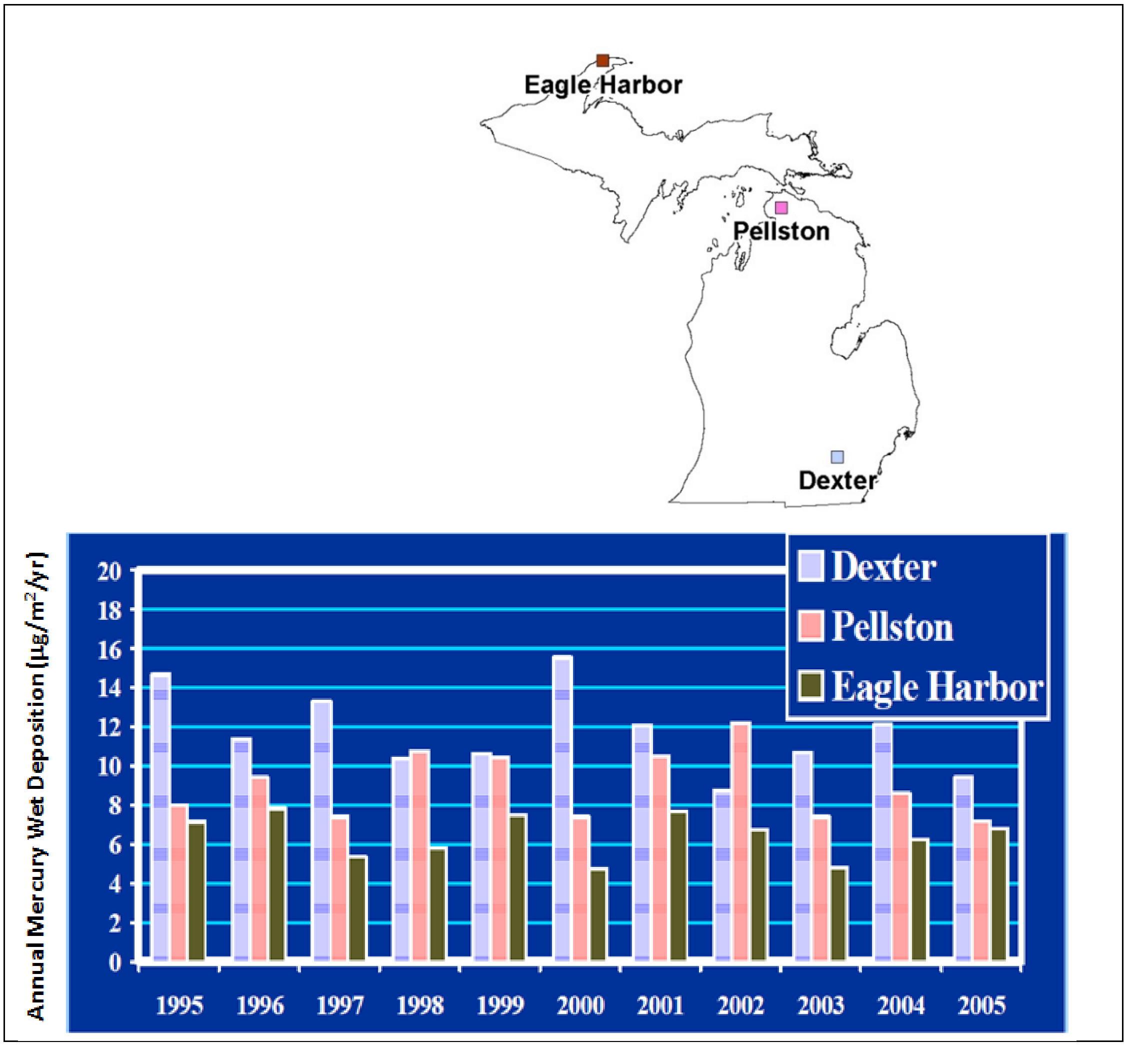


Figure 4. Annual Mercury Wet Deposition (µg/m^2/yr) from Event Precipitation Samples, 1995-2005.
Sampling locations are shown in the accompanying map above. (Source: MDEQ, 2008a)

A Minnesota study published in 2014 found a significant decrease in annual mercury wet deposition at 2 monitoring sites located in northern Minnesota from 1998 to 2012 (Brigham et al., 2014). In other parts of the country, particularly the northeast, a decrease in mercury wet deposition was noted in the northeast states (Prestbo and Gay, 2009; Butler et al., 2008).

Similar declines were identified in a 2016 publication (Zhang et al., 2016). This research found decreases in atmospheric Hg^0 concentrations ranging from 1.2 to 2.1% per year at northern mid-latitudes from 1990 to present. This paper also found that wet deposition trends in North America and Western Europe are similar to the trend found in atmospheric concentrations. The reductions were due to a significant reduction in mercury that was used in commercial products. The use peaked in 1970 and has been declining rapidly ever since, driving an overall global decrease in mercury release to the atmosphere over the 1970-to-2000 period (Horowitz et al., 2014). The overall reduction in atmospheric mercury and mercury in wet deposition was also a result of the significant reductions in mercury emissions from coal-fired electric utility boilers. U.S. mercury emissions from coal combustion declined by 75% between 2005 and 2015, primarily due to the co-benefits from controlling other atmospheric pollutants such as nitrogen oxide and sulfur dioxide from coal-fired electric utility boilers (Zhang et al., 2016).

Evers et al. (2011) reported long-term (1967-2009) trends of decreasing mercury in walleye and largemouth bass fillets, as well as herring gull eggs, across the Great Lakes states as a result of the widespread reduction in mercury emissions. Similar to reductions reported for the entire U.S., a 50% reduction in emissions was estimated for the 1990-2005 period for the Great Lakes states (Evers et al., 2011).

A 2014 publication found that, based on a suite of atmospheric and bioaccumulation models, fish mercury levels take up to 8 years to decline from mercury emission reductions, although these reductions may be offset by the mercury emission increase from global sources (Vijayaraghavan et al., 2014).

A study conducted by the United States Geological Survey (USGS) in northern Minnesota's Voyagers National Park from 2001 to 2012 found that mercury in 1-year old perch from 2 inland lakes decreased by 34.5%. Mercury in the water column declined by 46.5% during the same period (Brigham et al., 2014). This was the area where decreases in mercury deposition, as well as water column concentrations, were observed (Brigham et al., 2014).

Trend analyses have been conducted on datasets for fish collected from inland water bodies at an interval of 2 to 5 years for Michigan's Whole Fish Trend Monitoring Program. These data include carp from 5 inland river impoundments, and lake trout, walleye, and largemouth bass from 7 inland lakes. From 1990 to 2012, mercury concentrations in whole body fish samples from 5 of the 12 sampled inland water bodies showed a statistically significant trend - 1 increasing and 4 decreasing. The average annual rate of change decreased at 1.1% per year for all fish (Table 1; MDEQ, 2008b; MDEQ, 2015a).

In addition to the declines in air deposition and fish tissue concentrations, mercury reductions in other media have been documented. For example, reductions are being observed in sediment cores, herring gull eggs, as well as largemouth bass and lake trout within the Great Lakes region (Evers et al., 2011).

Table 1. Annual Rates of Change in Fish Tissue Mercury Concentrations for Whole Fish Collected from Fixed Station Trend Monitoring Stations.

Water Body	Sampling Period	Species	Rate of Change (%)	P Value
River Impoundments				
Grand River	1990 - 2011	Carp	±2.0	
Kalamazoo River	1990 - 2011	Carp	-1.1	0.04
Muskegon River	1991 - 2012	Carp	±1.9	
River Raisin	1991 - 2010	Carp	-2.6	<0.001
St. Joseph River	1991 - 2012	Carp	±1.6	
Inland Lakes				
Lake Gogebic	1992 - 2009	Walleye	-4.7	<0.001
South Manistique Lake	1991 - 2012	Walleye	±1.2	
Higgins Lake	1991 - 2011	Lake Trout	+3.6	<0.001
Houghton Lake	1992 - 2010	Largemouth Bass	±2.2	
Gull Lake	1991 - 2012	Largemouth Bass	-0.8	<0.001
Gun Lake	1991 - 2012	Largemouth Bass	±0.3	
Pontiac Lake	1992 - 2010	Largemouth Bass	±1.5	
		Average	-1.1	
		Median	-1.1	

A “±” symbol indicates no significant trend found (p>0.05). Average and median concentrations calculated using only those inland lakes and rivers with significant trend rates. (Source: MDEQ, 2008b; MDEQ, 2015a).

A report synthesizing mercury data for the Great Lakes region concluded that the scope of the impacts of mercury on fish and wildlife is much greater than previously recognized, with particular concern for inland waters. However, the science of mercury is complex and it is difficult to draw conclusions across the region or for one state (Evers et al., 2011). In spite of potential difficulties in assessing trends, elevated fish mercury concentrations observed in inland waters and published research (Chadwick et al., 2012; Evers et al., 2014) are sufficient to support the decisions regarding necessary reductions.

2.2 DATA COLLECTION AND ASSESSMENT OF WATER QUALITY

TMDLs must be developed for all water bodies contained on states’ Section 303(d) lists of impaired waters unless WQS are met before a TMDL is developed or the USEPA approves an alternative approach. This section begins with a discussion of the state’s data collection efforts used to support impairment determination, follows with a summary of waters impaired by mercury, and concludes with a discussion of the scope of water bodies considered under this TMDL.

2.2.1 Data Collection and Summary Analysis

Michigan uses the National Hydrography Dataset (NHD) to organize and identify water bodies for the Section 303(d) list. The base assessment unit is a 12-digit hydrologic unit code (HUC), which may be split further into subassessment units depending on information such as land use, known areas of contamination, specific fish consumption advisories, and physical barriers such as dams, etc. Each assessment unit is assigned an assessment unit identification number

(AUID) and may consist of all water bodies in a 12-digit HUC (as a maximum) or specific stream segments or lakes located in that HUC (MDEQ, 2012a).

Ambient Water Column Data

Water column samples analyzed for mercury were collected starting in 1970 and results are stored within the Michigan Surface Water Information Management System (MiSWIM)[4]. The Water Chemistry Monitoring Program (WCMP) began in 1998 with fixed sampling in Michigan's Great Lakes Connecting Channels, Saginaw Bay, Grand Traverse Bay, and selected tributary stations. A probabilistic design, or statistical sampling, was added to the WCMP in 2005 to gain the ability to extrapolate the data for statewide and regional analyses. The following evaluation discusses each component of the WCMP using the quality assured 5-year dataset from 2008-2012 (Varricchione et al., in preparation).

Great Lakes Connecting Channels

Total mercury concentrations are measured monthly from April through November at single upstream and downstream locations in each Great Lakes Connecting Channel (St. Marys River, St. Clair River, and Detroit River). These locations, 1 near the head and 1 near the mouth, are used to determine WQS attainment and measure water quality changes over time. Geometric means of the 2008-2012 data at each of the St. Marys and St. Clair River stations met the WQS with a range of 0.28-0.40 nanograms per liter (ng/L). Geometric mean concentrations in the Detroit River from 2008-2012 at 2.2 ng/L in the upstream station and 1.5 ng/L in the downstream station, both exceed the WQS of 1.3 ng/L.

Selected Tributaries Stations

The 2008-2012 data collected at 31 WCMP tributary stations indicate many Michigan rivers in their downstream reaches exceed the total mercury WQS of 1.3 ng/L. Twenty-seven stations were located near the mouths of rivers, and 4 watersheds had an additional mid-reach station to represent the upper reaches of those watersheds. Twenty-five of these stations were sampled 4 times per year for 4 years, with an intensification of 12 samples during its fifth year or "watershed year." The remaining 6 sites were identified as "intensive sites" and sampled 12 times during the open water period, every year. The geometric mean of total mercury data collected from 2008-2012 was calculated for each station with results ranging from less than quantification (<0.45 ng/L) to 5.2 ng/L. The WQS of 1.3 ng/L was exceeded at 24 of the 31 stations (i.e., 77% of the tributary stations).

Probabilistic River and Stream Analysis

This analysis includes 250 sites that are monitored over a 5-year period, resulting in 50 sites sampled per year. The geometric mean of total mercury data collected from 2008-2012 was calculated at each station. The WQS of 1.3 ng/L was exceeded at 97 of the 250 stations (39%). The statewide median value of total mercury is 1.1 ng/L, with median values at individual stations ranging from non-detect (<0.45 ng/L) to 8.65 ng/L. Approximately 50% of the river miles in Michigan are exceeding the WQS of 1.3 ng/L based on probabilistic data collected from 2009-2013 (Varricchione et al., in preparation).

Fish Tissue Data

[4] Available on the MDEQ's Web site at https://www.michigan.gov/egle/about/organization/water-resources/glwarm/my-waterway

Fish tissue samples are collected by a variety of agencies to provide data for assessment purposes as part of the Fish Contaminant Monitoring Program (FCMP). These agencies include, but are not limited to, the Michigan Department of Natural Resources, Fisheries Division; U.S. Fish and Wildlife Service; MDEQ; and Tribal governments. The edible portion monitoring program of the FCMP is used for the development of this TMDL. The edible portion program is used to make impairment determinations due to mercury in fish tissue, since its primary objective is to develop sport fish consumption advisories and commercial fishing restrictions. Therefore, this is the appropriate component of the FCMP for development of the TMDL. Mercury concentrations in fish tissue are available from the FCMP database for 39 species of fish collected between 1984 and 2009 from inland water bodies (Table 2). The average fish tissue concentrations were calculated by considering fish of all sizes from inland water bodies in the state.

Table 2. Average Mercury Fish Tissue Concentration for Edible Portion of Fish from Inland Water Bodies in Michigan 1984-2009.

Results in bold exceed TMDL target (0.35 mg/kg).
(Data source: FCMP, 2011)

Species	Number of Samples	Average Fish Tissue Concentration mg/kg (ppm)[a]
Black Buffalo	5	0.040
Black Bullhead	11	0.139
Black Crappie	238	0.213
Bluegill	134	0.155
Brook Trout	77	0.179
Brown Bullhead	140	0.150
Brown Trout	286	0.156
Bullhead	3	0.120
Burbot	10	**0.409**
Carp	1,743	0.178
Channel Catfish	236	0.185
Crappie	16	0.174
Freshwater Drum	20	**0.371**
Gizzard Shad	10	0.037
Goldfish	1	0.100
Lake Herring	34	0.236
Lake Trout	221	**0.408**
Lake Whitefish	44	0.131
Largemouth Bass	1,420	**0.401**
Longnose Sucker	1	**0.500**
Mirror Carp	1	0.050
Muskellunge	7	**0.483**
Northern Hogsucker	8	0.119
Northern Pike	1,941	**0.576**
Pumpkinseed	10	0.089
Rainbow Trout	38	0.141
Redear Sunfish	10	0.061
Redhorse Sucker	263	0.229
Rock Bass	580	0.223
Smallmouth Bass	720	0.294
Splake	35	0.158
Sunfish	5	0.352
Tiger Muskie	4	0.230
Walleye	1,913	0.474
White Bass	45	0.288
White Crappie	2	0.245
White Sucker	865	0.153
Yellow Bullhead	36	0.303
Yellow Perch	302	0.317

[a] Micrograms per kilogram of fish tissue (mg/kg); equivalent to parts per million (ppm).

The MDHHS uses fish tissue monitoring data when developing public health advisories for the Michigan Fish Consumption Advisory Program (MDHHS, 2013). Fish Consumption Screening Values are developed by the MDHHS to evaluate levels of chemicals commonly analyzed for, and found in, fish from Michigan water bodies. Fish Consumption Screening Values are used to recommend meal consumption categories (e.g., 1 meal per month versus 2 meals per month), and are protective for everyone, including vulnerable populations such as people with existing medical conditions and unborn and young children (Table 3). The MDEQ does not use the MDHHS statewide fish consumption advisory for determining designated use support.

Table 3. Mercury Fish Consumption Screening Values by Meal Category.
(Source: MDHHS, 2013)

Meal Category *meals per month*[a]	**Fish Consumption Screening Values Ranges** *µg/g (ppm)*[b]
16	≤ 0.07
12	> 0.07 to 0.09
8	> 0.09 to 0.13
4	> 0.13 to 0.27
2	> 0.27 to 0.53
1	> 0.53 to 1.1
6 meals per year	> 1.1 to 2.2
Do Not Eat	> 2.2

[a] Units are in months unless otherwise stated.
[b] Micrograms of chemical per gram of ww fish tissue (µg/g); equivalent to parts per million (ppm).

2.2.2 Discussion of Section 303(d) Listings

The MDEQ used the data described in Section 2.2.1 (excluding the MDHHS meal consumption guidelines) to assess water bodies in the state as either attaining the WQS for mercury or not supporting a water body's designated uses. Out of a total of 7,316 AUIDs across the state, 4,709 of those are listed as assessed waters (MDEQ, 2012a). Rivers and streams assessed for mercury are listed as impaired based on mercury concentration in both fish and water, while lakes are listed as impaired based on fish data, since water column concentrations of mercury in inland lakes are low and data are limited. Mercury-impaired water bodies are shown in Figures 5 and 6.

The MDEQ's methodology for assessing use support is described in Section 3.2 and the mercury-impaired AUIDs covered by this TMDL are described in Section 2.3.

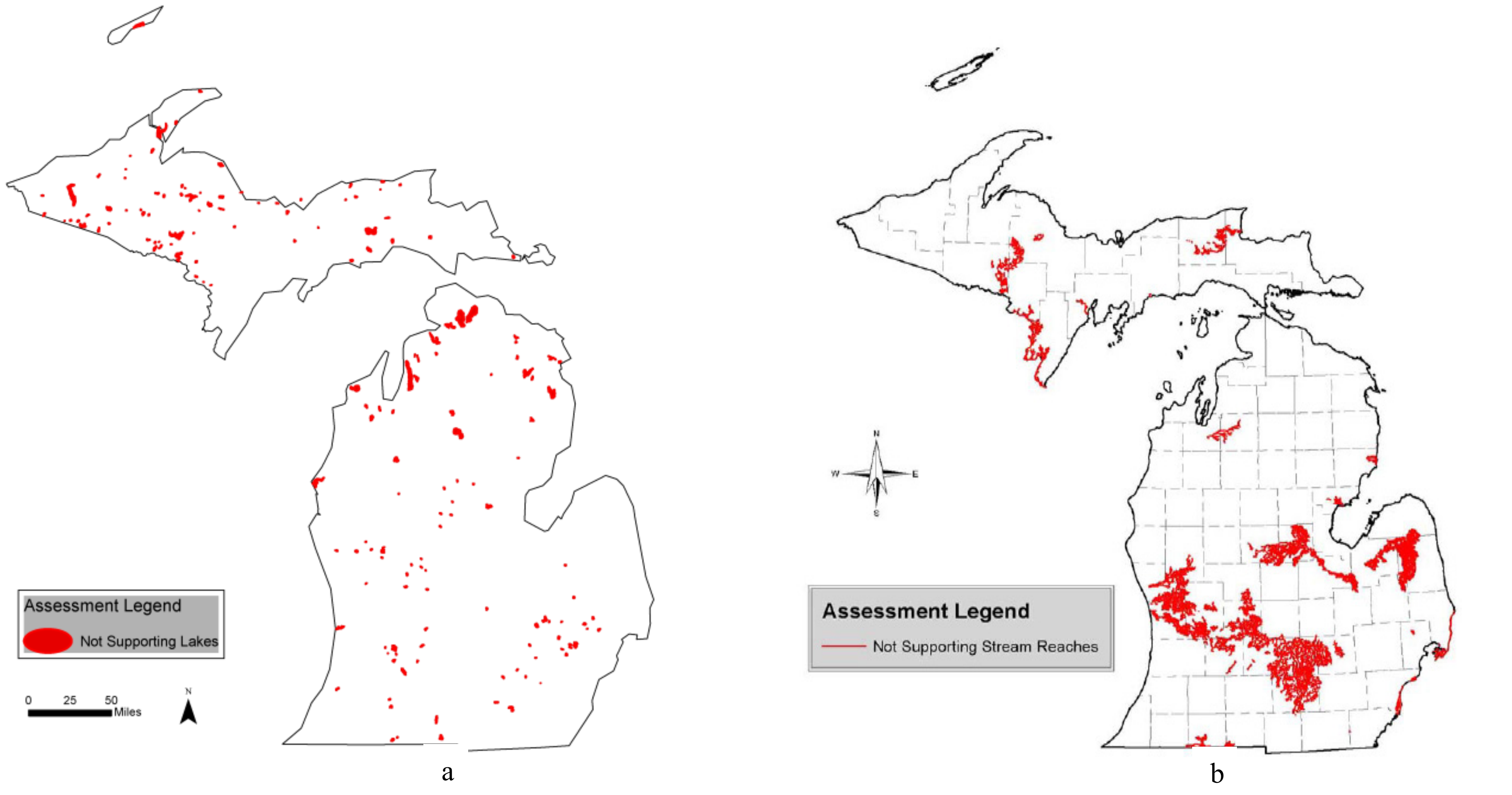


Figure 5. Mercury-impaired Rivers and Streams (a) and Lakes (b), Based on Fish Tissue Data.
(Data source: MDEQ, 2012a)

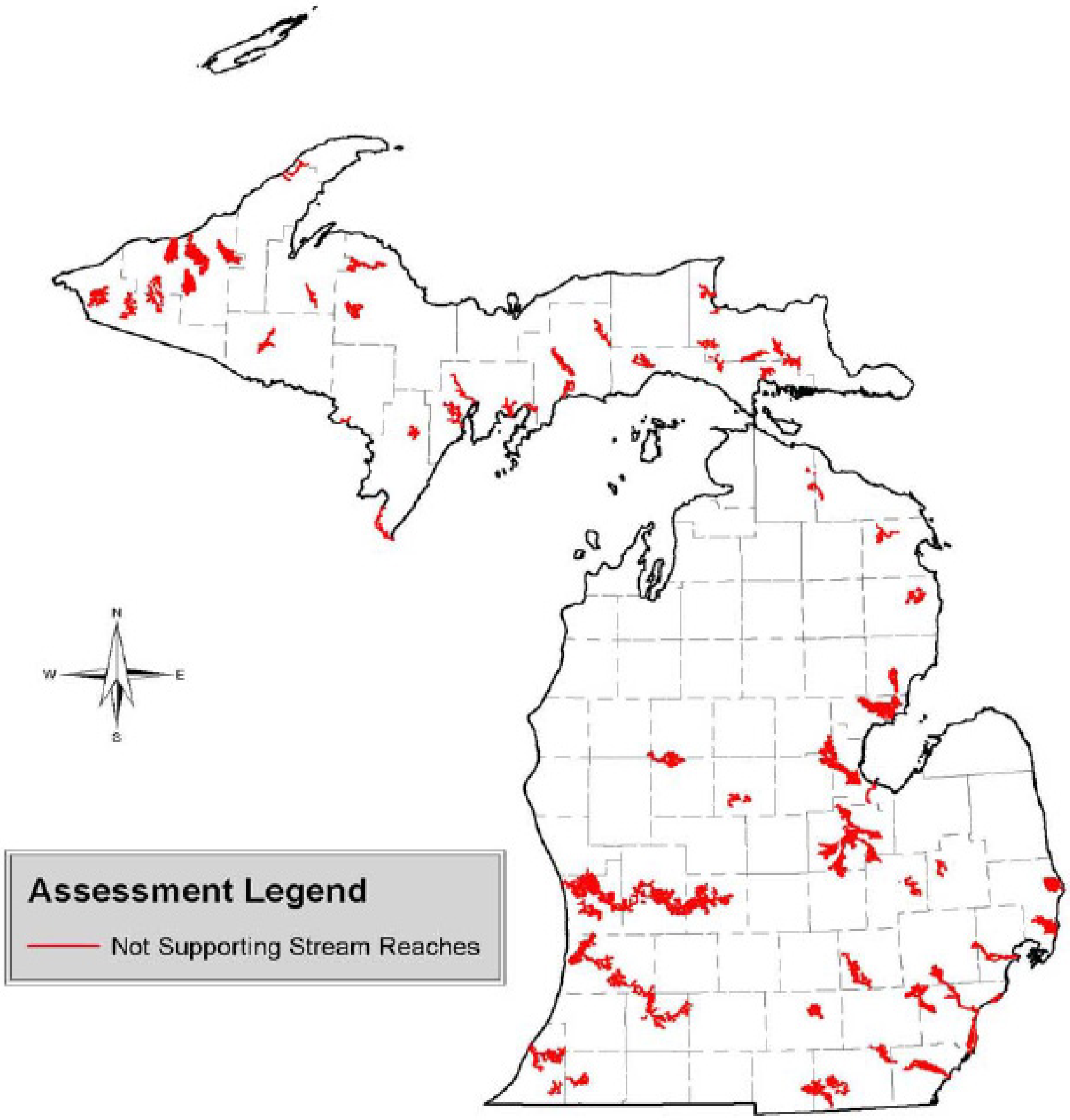


Figure 6. Mercury-impaired Rivers and Streams Based on Water Column Data.
(Data source: MDEQ, 2012a)

2.3 SCOPE OF WATER BODIES CONSIDERED UNDER THIS TMDL

The state of Michigan's plan for addressing waters impaired by mercury includes:

1. This statewide mercury TMDL that will cover all mercury-impaired inland water bodies of Michigan that are listed in Appendix A. Water bodies listed in Appendix A are expected to meet the WQS after implementing source reductions.

2. Waters covered under this TMDL will change based on future Section 303(d) lists based on the process outlined in Section 8.6.

3. The following waters are not covered by this TMDL:

    a. The Great Lakes and connecting channels (i.e., Lake St. Clair, St. Clair River, St. Marys River, Detroit River, and the Keweenaw Waterway) will benefit from the atmospheric reductions called for in this TMDL. However, the level of pollutant reduction required to achieve the WQS will be different than for inland waters due to different atmospheric deposition rates and much longer response times. These water bodies will be considered under a separate TMDL focused on the Great Lakes.
    b. Contaminated legacy sites (i.e., Areas of Concern [AOC] and Superfund sites) impacted by mercury are not covered by this TMDL. Formal cleanup plans are in place at these sites, and the water bodies are expected to meet the TMDL target once cleanup plans are complete and reductions described in this TMDL are achieved.
    c. A few inland water bodies, impaired primarily by atmospheric sources, may not meet the WQS after the reductions in atmospheric loading called for in this TMDL are achieved. In time, separate TMDLs may be developed for these water bodies if needed.

3 APPLICABLE WQS AND NUMERIC TARGETS

3.1 DESIGNATED USES AND WATER QUALITY CRITERIA

Section 303(c)(2)(A) of the federal Clean Water Act requires states to identify appropriate uses for all water bodies, and provide, where attainable, water quality (in the form of WQS) for the protection and propagation of fish, shellfish, and wildlife, and recreation in and on the water. Designated uses describe the various uses of waters that are considered desirable, and identify those waters that should be protected. At a minimum, all surface waters in Michigan are designated and protected for all of the following uses: agriculture, navigation, industrial water supply, warmwater fishery, other indigenous aquatic life and wildlife, partial body contact recreation, total body contact recreation (May 1 to October 31), and fish consumption. A select group of rivers and inland lakes are designated and protected for coldwater fisheries and public water supply (R 323.1100, Designated Uses, of the Part 4 Rules, WQS, promulgated under Part 31, Water Resources Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended [Act 451]).[5]

The WQS for water column mercury concentration are 0.0013 µg/L (or 1.3 ng/L) for the protection of wildlife, 0.0018 µg/L (or 1.8 ng/L) for the protection of human health, and 0.77 µg/L (as dissolved), and 1.4 µg/L (as dissolved) for the protection of aquatic life from adverse effects due to chronic and acute toxicity, respectively (R 323.1057, Toxic Substances, of the Part 4 Rules.

3.2 NUMERIC TMDL TARGET

TMDL targets are established at a level that attains and maintains the applicable WQS, including designated uses, numeric and narrative criteria, and antidegradation policy [40 CFR §130.7(c)(1)]. TMDL submittals must include a description of any applicable WQS, and must also identify numeric water quality targets, which are quantitative values used to measure whether or not applicable WQS are being attained. Depending on the designated use being addressed, a TMDL target may be based on human health, aquatic life, or wildlife criteria (USEPA, 2008a). Where possible, the water quality criterion for the pollutant causing impairment is used as the numeric water quality target when developing the TMDL. Because consumption of fish by humans and wildlife is the most significant route of exposure, the fish tissue residue value (based on a Trophic Level 4 fish) for mercury of 0.35 mg/kg was chosen as the target for this TMDL. Trophic Level 4 refers to the position in the food chain occupied by predatory species that consume other carnivores. Northern pike is representative of Trophic Level 4 fish, had the highest average mercury levels among the various fish species evaluated, and is also distributed throughout Michigan inland waters. Therefore, northern pike was selected as the target fish species for this TMDL and meeting the target of 0.35 mg/kg in northern pike should be protective of all other fish species. Mercury concentration in northern pike and derivation of the 90th percentile mercury concentration (used as an appropriate level of protection) are described in Section 4.0.

The MDEQ derived a Michigan fish tissue mercury residue value using the same methodology that the USEPA used to derive a national fish tissue criterion for mercury (USEPA, 2001a). The derivation of Michigan's fish tissue mercury residue value of 0.35 mg/kg for edible fish portions used the same Reference Dose (0.1 µg/kg/day) as the USEPA used to derive a national fish

[5] https://www.michigan.gov/-/media/Project/Websites/egle/Documents/Programs/WRD/NPDES/part-4-water-quality-standards.pdf

tissue residue value of 0.30 mg/kg, but used different fish consumption rate, body weight, and relative source contribution values (Table 4). Michigan's fish tissue residue value for mercury is the concentration that is not expected to pose a health concern to people consuming 15 grams or less of fish per day. Rather than using the national fish consumption rate and relative source contribution used by the USEPA in its calculations, the fish consumption rate, body weight, and relative source contribution used to derive the human health WQS of 1.8 ng/L were used. The methodology used to derive the fish tissue residue value of 0.35 mg/kg for mercury is therefore consistent with the methodology used by the USEPA to derive its fish tissue residue value, and is consistent with federal requirements for the Great Lakes basin (USEPA, 2001c).

Table 4. Reference Dose, Body Weight, Fish Consumption Rate, and Relative Source Contribution Comparison Between the National Fish Tissue Criterion and MDEQ's Fish Tissue Residue Value.

Fish Tissue Residue Value	USEPA (2001a) 0.30 mg/kg	MDEQ 0.35 mg/kg
Reference Dose	0.1 µg/kg/day	0.1 µg/kg/day
Body Weight	70 kg	65 kg
Fish Consumption Rate	National Value 17.5 grams/day	Region-Specific Value 15 grams/day
Relative Source Contribution	National Value 0.73	Region-Specific Value 0.8

Because the WQS protective of wildlife (1.3 ng/L) is lower than the value used to protect human health (1.8 ng/L), an evaluation was conducted by the MDEQ to determine whether the fish tissue residue value of 0.35 mg/kg would be protective of wildlife species such as loons, bald eagles, and mink that consumed smaller whole fish from the same waters. Based on this evaluation, the MDEQ determined that a mercury concentration of 0.35 mg/kg in edible fish portions from a legal size Trophic Level 4 fish would be protective of wildlife species consuming smaller whole fish from the same waters (MDEQ, 2012c).

4 MODELING APPROACH

4.1 RELATING ATMOSPHERIC LOADING TO FISH TISSUE CONCENTRATION

The approach for linking pollutant loads to environmental concentrations for this TMDL is patterned after the statewide mercury TMDL developed by the Minnesota Pollution Control Agency (MPCA) (2007) and a regional mercury TMDL for the Northeast U.S. (New England Interstate Water Pollution Control Commission [NEIWPCC], 2007).

Consistent with the Minnesota and Northeast U.S. TMDLs, this TMDL is based on the following assumptions: (1) a reduction in mercury emissions will result in a proportional reduction in the rate of mercury deposition; (2) a reduction in mercury deposition will result in a proportional decrease in mercury loading to water bodies; and (3) ultimately, a proportional reduction in loading in water bodies will result in a proportional decrease in mercury concentrations in fish.

The proportionality approach is based on the linear relationship between mercury levels in air and water, along with a bioaccumulation factor (BAF) to relate fish tissue concentrations to water column concentrations. The model is derived beginning with the standard, steady-state bioaccumulation equation: (USEPA, 2001b; NEIWPCC, 2007):

$$^{C}fish_{t1} = {}^{BAF} * {}^{C}water_{t1}$$

Where:
$^{C}fish_{t1}$ and $^{C}water_{t1}$ represent mercury concentrations in fish (mg/kg) and water (ng/L) at time t_1, respectively. The BAF is constant for a given age, length, and species of fish in a specific water body.

For a future time, t_2, when mercury concentrations have changed but all other parameters remain constant, the following equation applies:

$$^{C}fish_{t2} = {}^{BAF} * {}^{C}water_{t2}$$

Where:
$^{C}fish_{t2}$ and $^{C}water_{t2}$ represent mercury concentrations in fish and water at that future time t_2, respectively. The $^{C}fish_{t2}$ is for a fish that is the same age, length, and species as for $^{C}fish_{t1}$.

Combining the two equations produces the following:

$$\frac{^{C}fish_{t1}}{^{C}fish_{t2}} = \frac{^{C}water_{t1}}{^{C}water_{t2}}$$

Because water column mercury concentrations are proportional to mercury air deposition load, the above equation can be expressed as follows:

$$\frac{^{C}fish_{t1}}{^{C}fish_{t2}} = \frac{^{L}air_{t1}}{^{L}air_{t2}}$$

Where:
$^{L}air_{t1}$ and $^{L}air_{t2}$ are the air deposition mercury loads to a water body at time t_1 and t_2, respectively.

Thus, it is reasonable to predict that, under long-term, steady-state conditions and a linear relationship assumption, mercury fish concentrations will likely be reduced from current levels in direct proportion to reductions in the air deposition load.

The steady-state conditions represented in the model correspond to long-term average concentrations expected to eventually occur in response to long-term reduction in loading. Therefore, it is not expected that the proportional relationship between atmospheric deposition reductions and fish tissue reductions will be observed immediately. However, it is expected that the proportional response will be seen over the long term, once the systems have achieved steady state. Several dynamic, ecosystem scale models including the Mercury Cycling Model (MCM), and a modified version, the Mercury Maps Model, assume that, at steady-state, reductions in fish concentrations will be proportional to reductions in mercury inputs (USEPA, 2001b).

The Mercury Maps Model tool performs a national-scale assessment of the change in fish methylmercury concentrations resulting from reductions in atmospheric deposition of mercury. The model states that for long-term, steady-state conditions, reductions in fish tissue concentrations are expected to track linearly with reductions in air deposition watershed loads. The Mercury Maps approach is based on the assumption of a linear, steady-state relationship between concentrations of methylmercury in fish and present day air deposition mercury inputs. The USEPA states, however, that this condition may not be met in many water bodies because of recent changes in mercury inputs and other environmental variables that affect mercury bioaccumulation. Therefore, the USEPA has also acknowledged that a significant lag time will occur from a reduction in mercury deposition to when a reduction in methylmercury concentrations in fish occurs.

Application of the E-MCM[6] Model (Everglades - MCM) to the Florida Everglades predicted a linear relationship between atmospheric mercury deposition and mercury concentrations in largemouth bass (Atkeson et al., 2003). In this study, mercury levels in largemouth bass were predicted to attain 50% of their long-term, steady-state response in about 10 years, given continued reductions in mercury loads. In 30 years, mercury levels in largemouth bass are predicted to attain 90% of their long-term, steady-state response.

4.2 ATMOSPHERIC DEPOSITION OF MERCURY

Estimates of total atmospheric deposition (both wet and dry) of mercury for Michigan were obtained from the USEPA’s Regional Modeling System for Aerosols and Deposition (REMSAD; USEPA, 2008b) Model (Figure 7). REMSAD is a “three-dimensional grid model designed to calculate the concentrations of both inert and chemically-reactive pollutants by simulating the physical and chemical processes in the atmosphere that affect pollutant concentrations” (USEPA, 2008b). The REMSAD Model simulates both wet and dry deposition of mercury, and incorporates a simplified procedure to track the reemission (evasion) of previously deposited mercury (via wet and dry deposition). The reemitted mercury, in turn, becomes an emission source and contributes to mercury deposition. Wet deposition occurs as a result of precipitation scavenging, in which mercury is removed from the air by attaching to water vapors or rain/snow. Dry deposition occurs when gas phase and particulate-bound mercury are deposited on terrestrial surfaces. The Particle and Precursor Tagging Methodology feature of REMSAD allows the user to tag or track emissions from selected sources or groups of sources, and

[6] E-MCM is the modified version of MCM developed for the Florida Everglades.

quantify their contribution to mercury deposition throughout the modeling domain and simulation period.

The REMSAD Model was applied at a national scale. The year 2001 was chosen as the annual simulation year because REMSAD Model inputs (emissions and meteorology) were primarily derived from the 2001 Clean Air Interstate Rule database, which the USEPA used in the evaluation of the Clean Air Interstate Rule and the Clean Air Mercury Rule.

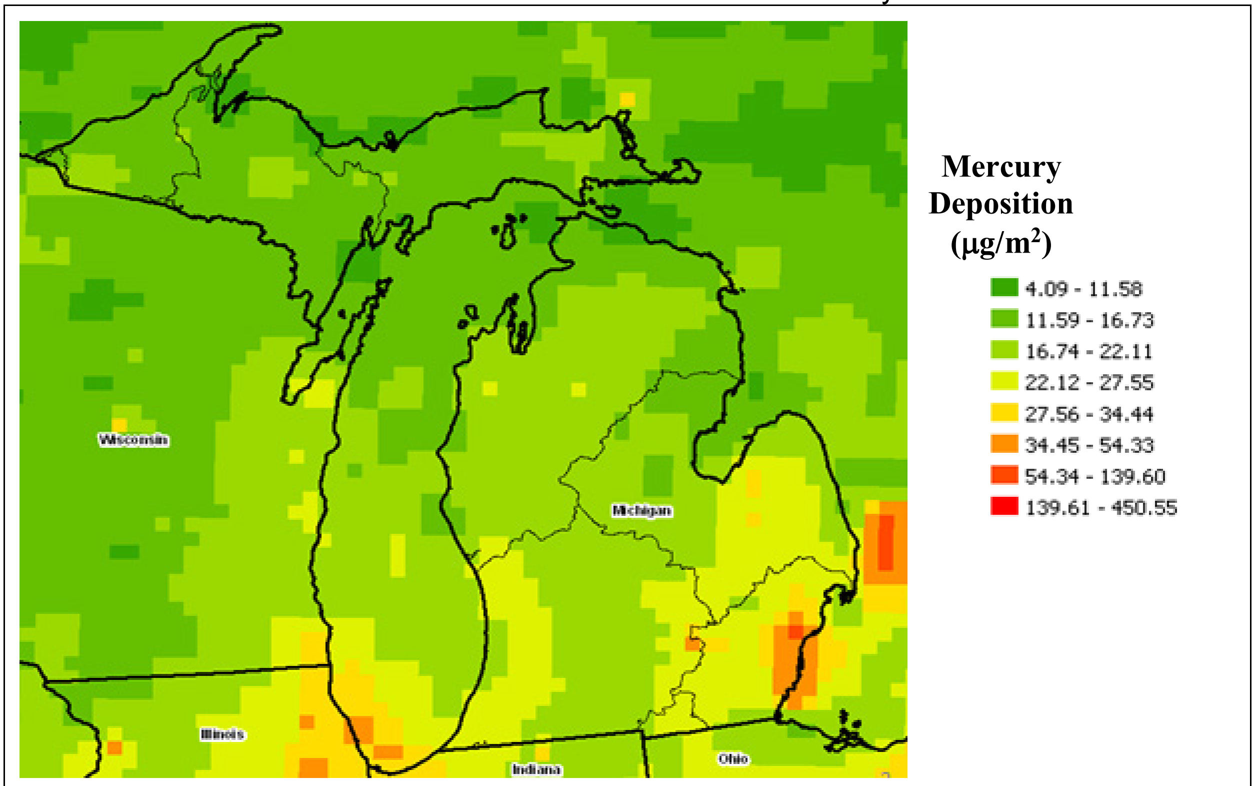


Figure 7. Mercury Deposition Predicted for Michigan (2001) by the REMSAD Model.
(Source: USEPA, 2012)

Although 2001 was used for calculating air emission reductions, progress toward meeting the TMDL will be tracked from a 2002 air emissions baseline developed as part of the MDEQ Mercury Strategy (MDEQ, 2008a). There are 3 reasons for tracking the progress of this TMDL using the 2002 air emission inventory: (1) Michigan does not have a detailed mercury air emissions inventory for 2001; (2) it is likely that the mercury air deposition values did not change significantly between 2001 and 2002; and (3) atmospheric mercury reductions will be primarily tracked by emission measurements because there is currently no funding for measuring widespread atmospheric mercury deposition in the state.

Based on the MDEQ mercury air emission inventory for 2002, the MDEQ determined that the emission inputs corresponding to Michigan sources were likely underestimated in the REMSAD Model by approximately 2,000 pounds. The underestimate was due to the omission of “area sources,” which include leakage and volatilization from breakage and disposal of mercury-containing products such as thermometers, switches, and fluorescent light bulbs (MDEQ, 2008a)[7].

To evaluate the spatial differences in atmospheric mercury concentrations across the state, Ecological Drainage Units (EDU; Higgins et al., 2005) were used to aggregate areas of the state containing similar mercury atmospheric deposition rates. EDUs are a method of spatially organizing the state based on areas of similar biotic and abiotic characteristics such as freshwater fish and invertebrate species composition and distribution, climate, and physiography. They generally range from 1,000 to 10,000 square kilometers (km^2) in size, but can be much bigger. There are ten major EDUs in Michigan[8]. The largest EDU (i.e., Northern Lake Michigan, Lake Huron, and Straits of Mackinac) is about 38,000 km^2. Although the EDU boundaries align with watershed boundaries, such that no impaired stream segments will span multiple regions, they are not necessarily true watershed boundaries (Higgins et al., 2005). The 10 major EDUs in Michigan are shown in Figure 8.

[7] The reduction needed for this TMDL will not be affected by the underestimate because the reduction is based on fish tissue concentrations (See Section 4.5). The use of the 2002 emissions inventory for tracking reductions addresses this underestimate by requiring a similar reduction from all sources covered under this TMDL, including those omitted from the REMSAD Modeling.

[8] There are a total of 13 EDUs in the state of Michigan. The Chippewa-Black River, Wisconsin, and Upper Illinois River EDUs are extremely small areas relative to the remainder of the EDUs. Therefore, these three EDUs were merged together for an overall deposition of mercury from Michigan to the Upper Mississippi River watershed. There are less than ten miles of river segment that flow into the Upper Mississippi River watershed. The “To Be Determined” EDU was merged with the Eastern Upper Peninsula EDU.

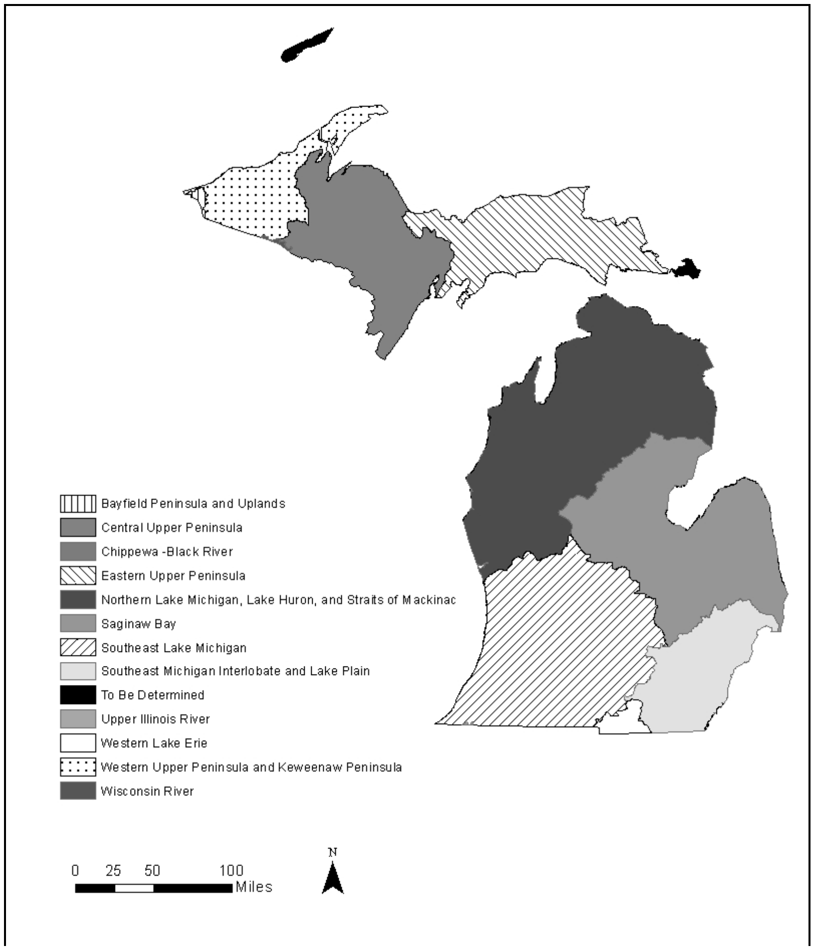


Figure 8. EDUs in Michigan.
(Source: Higgins et al., 2005)

Table 5 summarizes the REMSAD-predicted atmospheric mercury deposition for 2001 across each EDU in the state. The deposition rates are mapped in Figure 9 and were calculated as mercury deposition (g) divided by EDU area (km^2). The total statewide deposition rate (18.6 $\mu g/m^2$) was calculated as the mass of total mercury deposited over the sum of all the EDU areas. Deposition rates are seen in Table 5 to vary by EDU. This variability is discussed in Section 4.4.

Table 5. 2001 Annual Atmospheric Mercury Deposition for the State Resolved by EDU.
(Source: USEPA, 2012)

EDU	Area (km^2)	Mercury Deposition (g)	Deposition Rate ($\mu g/m^2$)
Bayfield Peninsula and Uplands	238	3,885	16.3
Chippewa - Black River, Wisconsin River, Upper Illinois River	128	2097	16.4
Western Upper Peninsula and Keweenaw Peninsula	8,575	127,537	14.9
Central Upper Peninsula	17,421	247,112	14.2
Eastern Upper Peninsula	15,568	224,290	14.4
Northern Lake Michigan, Lake Huron, and Straits of Mackinac	38,004	665,083	17.5
Saginaw Bay	26,494	541,046	20.4
Southeast Lake Michigan	29,063	629,632	21.7
Southeast Michigan Interlobate and Lake Plain	10,579	267,022	25.2
Western Lake Erie	1,172	26,156	22.3
Totals	**147,243**	**2,733,859**	**18.6**

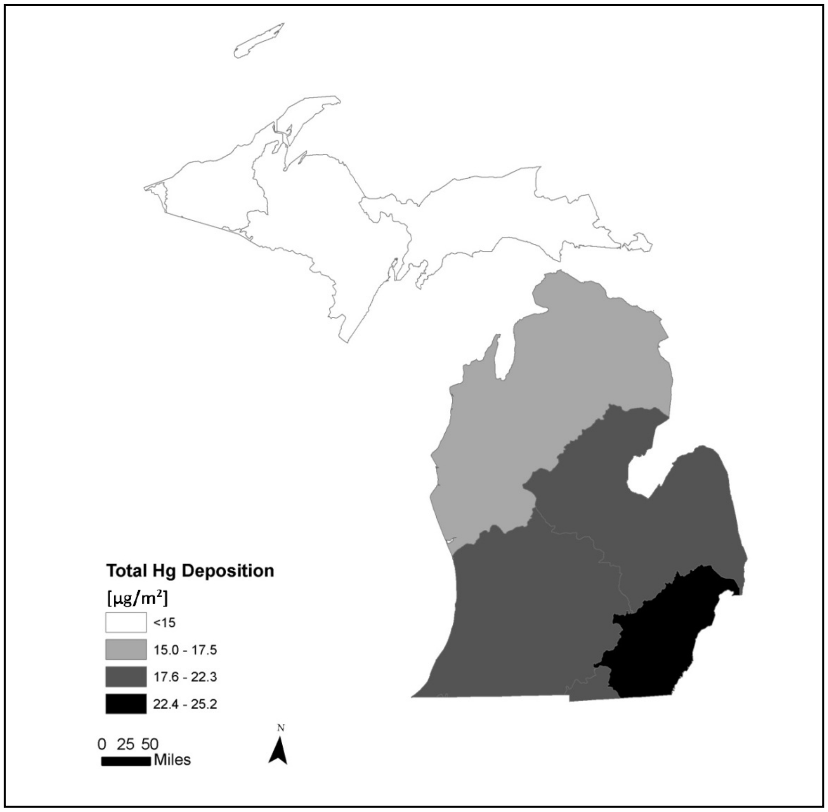


Figure 9. Modeled Mercury Deposition Rate by EDU for 2001 Conditions.
(Source: USEPA, 2012)

Another atmospheric modeling study was conducted during preparation of the MDEQ statewide mercury TMDL. This study was conducted by the U of M and was funded by the USEPA's GLRI (Marsik et al., 2014). This study was funded to provide estimates of the spatial distribution of total mercury (both wet and dry) to the state of Michigan and the surrounding states. Results of the study were also used to estimate the change in deposition with reduced emission scenarios. The study compared daily event rainfall samples collected by the U of M to evaluate the model performance. Because the ambient data were primarily available for 2005, this was the baseline emission inventory that was utilized for the atmospheric model.

The researchers used several models and data including the Weather Research and Forecasting Model, USEPA's National Emissions Inventory, and updated data from the MDEQ's emission data inventory. The weather and emission inventory data were entered into the Sparse Matrix Operator Kernel Emissions Modeling System to generate hourly emissions of mercury. The emissions (and Weather Research and Forecasting Model output) were used as input into the USEPA's Community Multi-scale Air Quality Model (CMAQ). The CMAQ Model generated hourly ambient speciated-mercury concentrations and deposition, for both wet and dry atmospheric deposition over 3 physical modeling domains (36, 12, and 4 km) that were part of a nested configuration. The 36 km grid covered the continental U.S. and parts of Canada and Mexico, the 12 km grid covered the northeastern U.S. and the 4 km grid covered the Great Lakes watershed, including the state of Michigan (Figure 10). A significant amount of quality assurance went into comparing the model results and observed values, including various meteorological conditions. The study generated 60 terabytes worth of data, which included meteorological, modeling, and emissions data. The principle investigators found the U of M model did a reasonable job of predicting the location of observed precipitation, although the modeled precipitation was consistently higher than actual precipitation (Figure 11). An over-estimate of precipitation was made in southeast Michigan, which resulted in an over-estimate of incineration contribution to deposition in the Flint area.

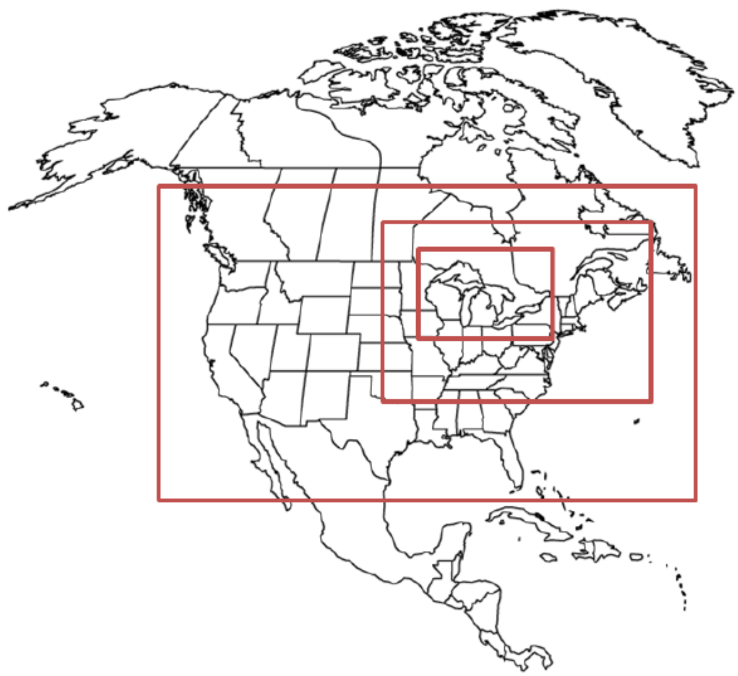


Figure 10. Weather Research and Forecasting Model Modeling Domains.

(Source: Marsik et al., 2014)

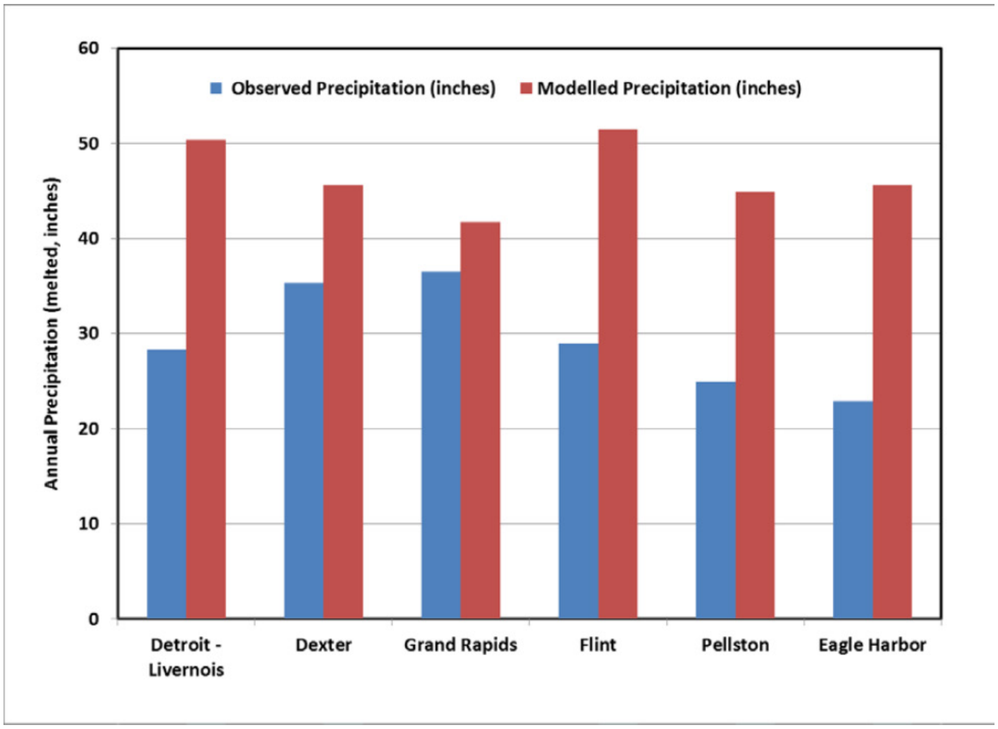


Figure 11. Comparison of Modeled and Measured Precipitation for Select Locations for Calendar Year 2005 Weather Research and Forecasting Model BASE CASE Simulation.

While different baseline emission years were utilized for the REMSAD and CMAQ Model runs, some qualitative comparisons can be made. Both models found that background or global sources contributed most of the mercury deposited in the state of Michigan. The highest deposition was in southeast Michigan, and decreased when moving north in Michigan. For the CMAQ Model simulation the counties with the highest mercury emissions in Michigan were: Monroe, Wayne, St. Clair, Alpena, and Ottawa.

The U of M study also characterized both wet and dry deposition. Dry deposition was found to be higher in more urban areas with more local impact due to the deposition from particulate bound and oxidized mercury. Comparison of wet and dry deposition at specific locations in Michigan can be found in Figure 12. The Flint disparity is thought to be a result of the location used for the Flint receptor site. A receptor site is where the historical atmospheric data were utilized in receptor modeling. The receptor site chosen to represent the Flint area was in close proximity to the gridded emissions used in the modeling effort. This resulted in elevated deposition estimates for receptor locations within or next to the model grid cells with anthropogenic emissions. The emissions within model grid cells are instantly dispersed across the entire grid cell resulting in strong deposition to that, or adjoining, grid cells (Marsik et al., 2014). In reality, emissions may be deposited farther downwind, because they stay aloft within elevated plumes. This results in dry deposition values that are likely much less than predicted by the model.

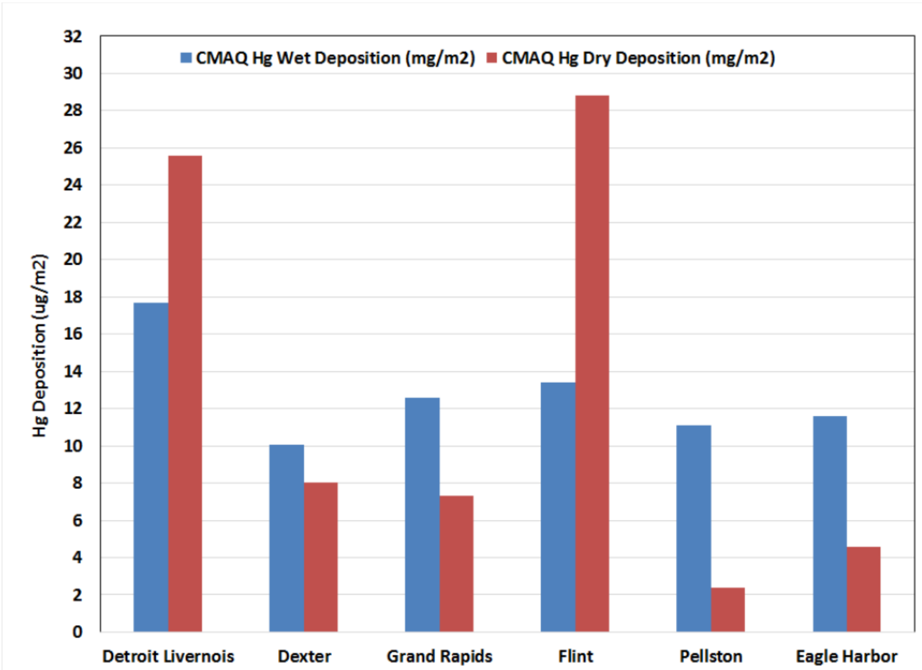


Figure 12. Summed Annual (2005) CMAQ Model BASE CASE Simulation Mercury Wet and Dry Deposition (µg/m2) at a Select Series of Locations Across the State of Michigan.

Additionally, the U of M researchers provided a comparison of total deposition from both the REMSAD and CMAQ Models. The REMSAD Model estimated a state-wide deposition rate of 18.6 µg/m^2 and the CMAQ Regional Chemical Modeling results from the U of M study resulted in an estimated statewide mercury deposition of 21 µg/m^2. The statewide deposition from both models found the highest deposition in southeast Michigan, where the highest emissions are located. The U of M study also estimated deposition reductions that could result in emission reduction scenarios. The results of the reduction scenarios are discussed in Section 6.4 of the TMDL document.

4.3 APPLYING THE NUMERIC TMDL TARGET

Because the mercury TMDL is applied statewide and considers a wide range of fish tissue concentrations, it would not be practical to base TMDL reductions on the requirement that every fish in the state have concentrations lower than the fish tissue residue value of 0.35 mg/kg. Instead, the selection of a numeric fish tissue target should be based on a specific fish tissue residue value, an appropriate fish species, and a statistical level at which to base agreement with the TMDL once reductions of atmospheric mercury concentrations have been made.

Figure 13. Photo of a Northern Pike.
(Photo credit: Tim Cwalinski)

4.3.1 Selection of a Target Fish Species

Michigan's FCMP database, which includes mercury data in edible portions of fish tissue collected from 1984 to 2009, was used to identify which fish species would serve as the basis for required TMDL loading reductions. Only slight statistical trends have been observed in mercury concentrations monitored in fish from inland lakes since 1990 by the MDEQ's Trend Monitoring Program (MDEQ, 2008b; MDEQ, 2015a). Therefore, the entire fish dataset spanning 1984 to 2009 was used in evaluating the species of fish on which to base mercury reductions. Only data from the edible portion (i.e., skin-on and skin-off fillets) were considered since these are the data that support the fish consumption designated use. Fish tissue mercury concentrations have been sampled in a wide range of species across Michigan and show varying degrees of bioaccumulation.

Mercury concentration data for edible portions (fish fillets) of fish tissue were available for 11,435 samples, from 39 species of fish, spanning the collection period of 1984 to 2009. The distribution of concentrations suggested that northern pike (*Esox lucius*) have the highest mercury concentrations of all species in the state (Table 2). Using all of the mercury data available for northern pike (1,941 fish fillet tissue samples), an average mercury concentration, regardless of size, was calculated to be 0.576 mg/kg. Northern pike (Figure 13) was selected as the target species for this TMDL, since this species represents a top-predator species, has the highest mercury concentrations of fish species evaluated, is widely distributed throughout the state, and is considered to be a game species readily sought after and consumed by anglers.

The accumulation of mercury in fish tissue increases with age and length of the fish. To account for this size-dependency of mercury concentration, it is necessary to statistically standardize the data such that mercury concentrations can be compared for fish of the same size referred to as standard size, or standard length fish. To avoid biases caused by different prevailing fish sizes and growth rates at different sampling times and locations, standardized-length northern pike mercury concentrations were calculated for each sampling event. The standardized northern pike length used in this TMDL is 24 inches (61 centimeters), which corresponds to the minimum legal size for this species in Michigan. This standard size also compares well with the overall average northern pike length of 23.8 inches (60.5 centimeters) from inland lakes and impoundments (MDEQ, 2008b; MDEQ, 2015a). The mercury concentration in a standard length fish was calculated from the available northern pike data for each field collection date using a linear regression statistical procedure. Fish datasets were first stratified by water body and collection date. Then linear regression was conducted on fish tissue mercury concentrations versus length. When statistically significant ($P < 0.05$) regressions were obtained, regression results were used to predict standard length fish concentrations. Approximately 50% of the regression results were statistically significant. An example length-concentration regression for northern pike in Torch Lake is shown in Figure 14. Average concentrations of mercury in fish tissue were used when regressions were not statistically significant.

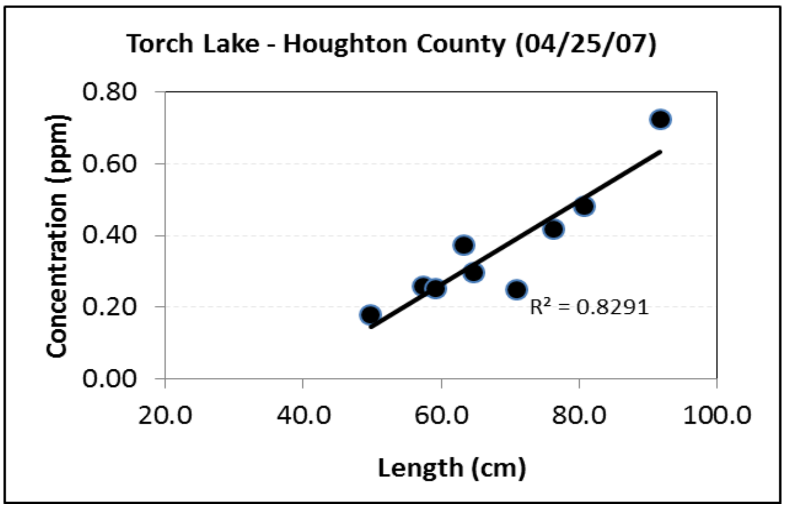


Figure 14. A Regression of Fish Length versus Fish Tissue Concentrations for Northern Pike from Torch Lake in Houghton County, Michigan.

4.3.2 Selection of a Statistical Level for Defining TMDL Reductions

A cumulative frequency distribution of length-standardized northern pike mercury concentrations across Michigan inland water bodies was developed (Figure 15). The 90th percentile concentration obtained from the frequency distribution plot was selected for determining the mercury load reduction in this TMDL. Both the Minnesota and Northeast U.S. mercury TMDLs used the 90th percentile as the basis of their TMDL. The justification for selecting the 90th percentile included:

- The 90th percentile of samples from a given water body has been used as assessment guidance by the USEPA (i.e., no more than 10% of the samples can exceed the WQS) (USEPA, 2000).

- Targets were based on tissue concentrations for fish species shown to be top predators with high mercury bioaccumulation potential. Achieving the target level for the 90th percentile of the fish species (northern pike) with the highest mercury concentration ensures that the overwhelming majority of fish in lower trophic levels will meet the target level.

- As fish mercury levels are reduced and the 90th percentile approaches the target value, the concentration difference between the 90th and higher percentiles is likely to be very small.

The 90th percentile of length-standardized mercury concentrations in northern pike is shown graphically in Figure 15. The dashed vertical line indicates the target concentration (0.35 ppm); the solid line indicates the current 90th percentile (1.012 ppm) concentration.

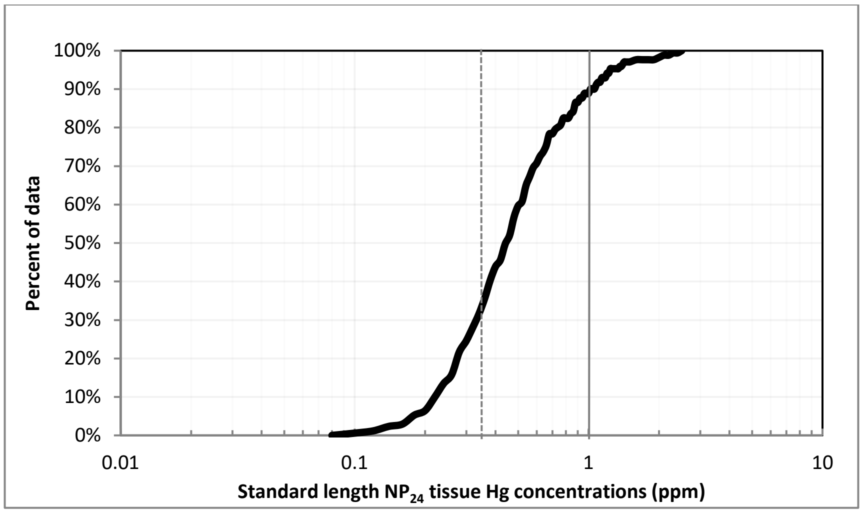


Figure 15. Cumulative Distribution of Length-Standardized Mercury Concentrations in Northern Pike.

In summary, the mercury load reductions required by this statewide TMDL will be based on the decrease in fish tissue mercury concentrations of a standard length northern pike, $NP_{24.}$ (MPCA, 2007). Utilizing the 90th percentile of standardized northern pike as the baseline to achieve reductions below the target concentration of 0.35 ppm will ensure that smaller predator fish and fish at lower trophic levels will meet the fish tissue residue target established for the mercury TMDL.

4.4 REGIONALIZATION

Statewide TMDLs can be developed either using a single statewide average loading reduction or by dividing the state into geographic regions to produce a loading reduction unique to each region. Detailed investigations were made into a variety of potential regionalization schemes, and a single, statewide average reduction percentage for atmospheric mercury deposition was selected. In Michigan, higher mercury bioaccumulation in fish occurs in the northern part of the state (Figure 16), but a corresponding higher atmospheric deposition rate of mercury does not occur in the same area (Figure 9). Studies have found that higher mercury concentrations in fish in the north do not necessarily correspond to higher atmospheric mercury deposition. It was therefore determined that other site-specific processes were contributing to higher fish tissue concentrations within individual lakes, such as water chemistry (i.e., nutrients, sulfate, and dissolved organic carbon); spatial land cover and land use, which can affect the uptake of mercury in fish; and transport of mercury from the surrounding watershed (e.g., Knauer et al., 2012; Mast and Krabbenhoft, 2010). A policy decision was made by the MDEQ to calculate a single, statewide average reduction percentage for atmospheric mercury deposition. As discussed in Section 2.3, the water bodies (where it cannot be established that fish tissue target concentrations will be met after implementing air deposition reductions called for in this TMDL) will be studied and addressed by other means, such as site-specific TMDLs or other alternative approaches (USEPA, 2013). If future monitoring shows that these water bodies are in compliance with the WQS, then no further work will be required.

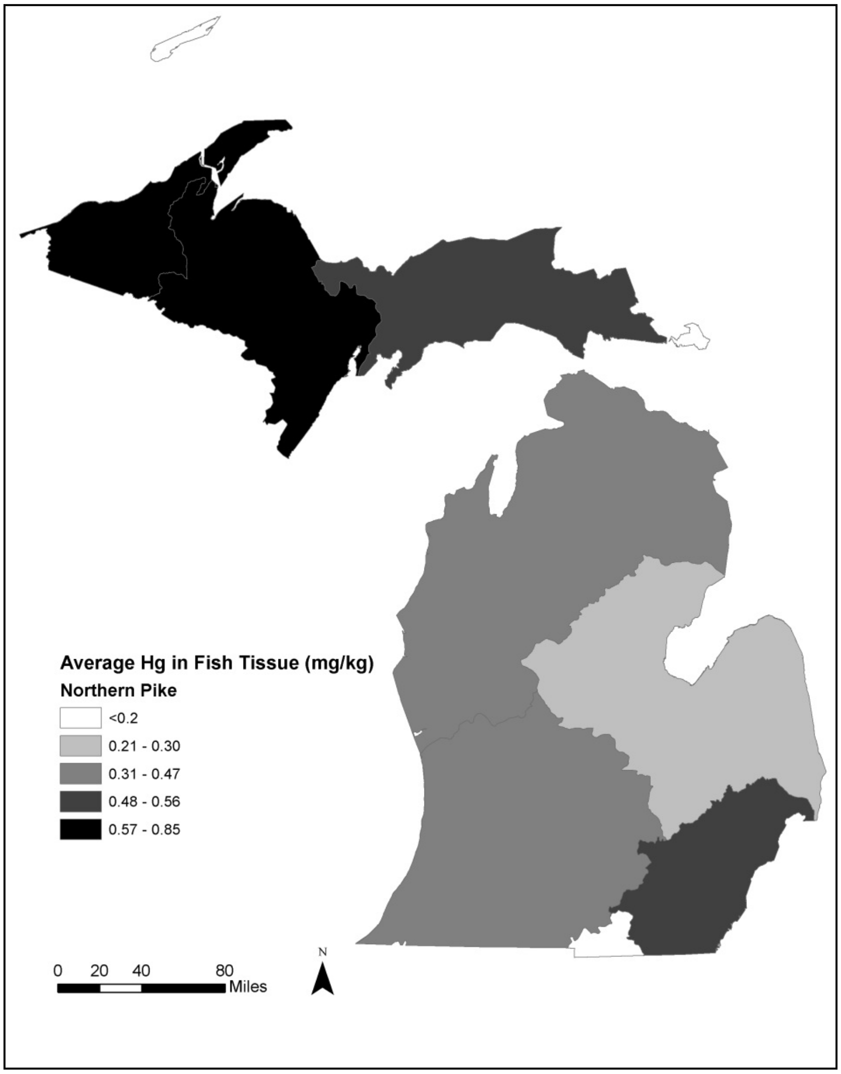


Figure 16. Average Mercury Concentration in Edible Portions of Northern Pike by EDU.
(Data Source: FCMP, 2011)

4.5 REQUIRED OVERALL REDUCTION PERCENTAGE

The overall reduction percentage required to meet TMDL targets were determined through the following steps:

1. Calculating the average 90th percentile mercury fish tissue concentration in edible portions of northern pike for the state.

2. Calculating the reduction factor (RF) to determine the percentage by which the 90th percentile of existing mercury northern pike fish tissue concentration would need to be reduced to attain the 0.35 mg/kg fish tissue target statewide.

3. Applying this reduction percentage to the 2001 atmospheric mercury deposition based on the assumption that there is a linear load-response relationship between fish tissue, atmospheric mercury deposition, and mercury emissions.

The calculation of the RF is based on the reductions necessary to achieve the target fish tissue mercury concentration compared to the 90th percentile existing mercury concentration in fish tissue. (Equation 1)

$$RF = (NP24_{90} – TF)/ NP24_{90} \quad \textbf{(1)}$$
$$RF = 1.012 – 0.35/1.012$$
$$RF = 0.6542$$

Where:
$NP24_{90}$ is the 90th percentile fish tissue mercury concentration in 24-inch northern pike and TF is the target fish tissue mercury concentration of 0.35 mg/kg.

The 90th percentile fish tissue mercury concentration for a 24-inch northern pike is currently 1.012 mg/kg. Applying the target concentration of 0.35 mg/kg in the equation above results in an RF of 0.6542 (65.42%). Because not all of the atmospheric sources are controllable (due to contribution from natural sources), details of how the RF was applied to atmospheric deposition is explained in Section 6.

5 SOURCE ASSESSMENT

5.1 MERCURY SOURCE CATEGORIES

Natural and anthropogenic sources are the 2 major types of mercury that contribute to atmospheric loadings in Michigan's inland water bodies.

It is possible to categorize mercury sources by origin. The REMSAD Model estimated that in 2001, 75.3% of atmospheric mercury deposition to Michigan originated from background sources. "Background" refers to natural sources as well as anthropogenic sources outside of North America. Surrounding states and Canada (i.e., regional sources) contribute 9.7% of atmospheric deposition, while other U.S. states and Mexico contribute 3.8% (Table 6). Approximately 3.4% of mercury deposition comes from reemission (defined as previously deposited mercury, which has been volatilized from water, land or vegetation, or evasion). The remaining 7.8% of atmospheric mercury deposition is contributed by sources within Michigan (Figure 17).

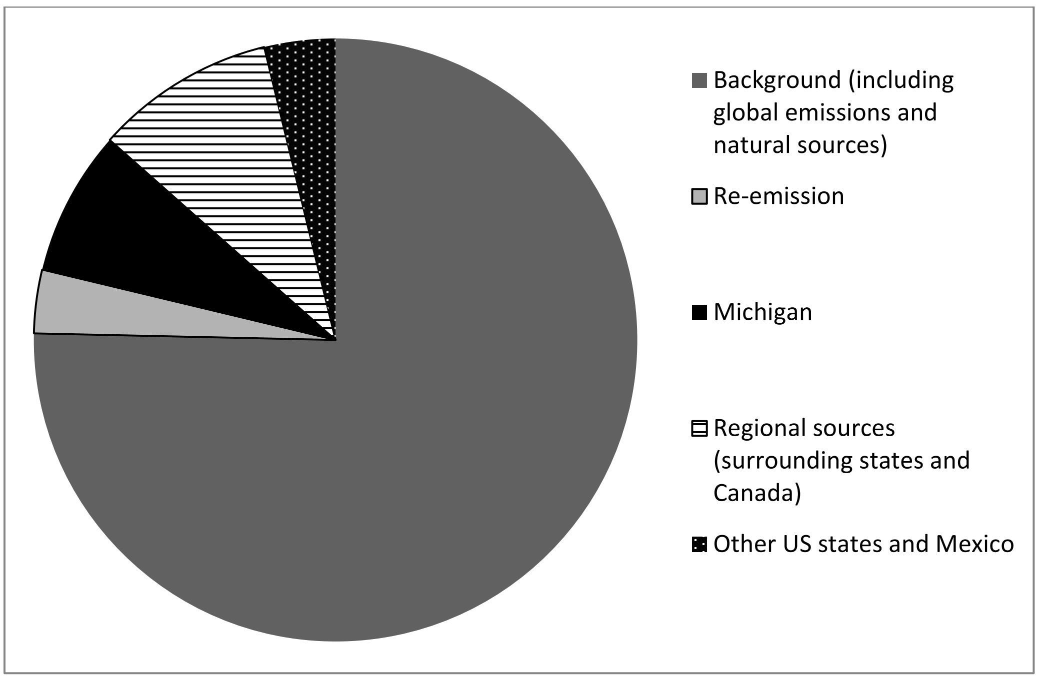


Figure 17. Distribution of Sources of Atmospheric Mercury Deposition to Michigan.
(Source: USEPA, 2012)

Table 6. Atmospheric Mercury Load by Source Category for Michigan, Surrounding States, Canada, and Mexico (Source: USEPA, 2012)

Source Category of Atmospheric Mercury	Load (kg)	Load (lbs)	% Load
Background	2,060	4542	75.3%
Re-emission	93	205	3.4%
Michigan	213	470	7.8%
Loading from surrounding states and Canada (total)	264	582	9.7%
Illinois	*58*	*128*	*2.1%*
Indiana	*41*	*90*	*1.5%*
Minnesota	*5*	*11*	*0.2%*
Ohio	*62*	*137*	*2.3%*
Wisconsin	*32*	*71*	*1.2%*
Canada	*66*	*146*	*2.4%*
Loading from other U.S. states and Mexico	104	229	3.8%
Total	**2,734**	**6,027**	**100.0%**

5.1.1 Natural Sources

There are no significant natural sources of mercury in Michigan, unlike other parts of the U.S. such as California, where certain mountain ranges are rich in cinnabar deposits. Atmospheric releases of mercury from forest fires, volcanoes, and geothermal sources in other areas of the U.S. and around the world can result in atmospheric deposition in Michigan (MDEQ, 2008a). In Michigan, forest fires and "background" soils (that have low mercury concentrations and have not been enriched by geologic process) can reemit previously-deposited mercury back to the atmosphere (MDEQ, 2008a).

5.1.2 Anthropogenic Sources

As described in Section 2, anthropogenic sources of mercury are varied and widespread despite recent efforts to reduce releases. Throughout the U.S., electrical production, coal combustion, paint formulated with phenyl mercuric acetate, laboratory use, and combustion of crude oil were the largest sources of mercury air emissions from 1930 to 2000. A significant overall drop in emissions occurred in 1990 (MPCA, 2007), due primarily to a reduction of mercury in products such as paints. Based on the MDEQ's 2002 emissions inventory (Appendix C), the single largest anthropogenic source sector of mercury emissions to the atmosphere was coal combustion from coal fired power plants, also known as electrical generating units. Based on the emission inventory conducted in 2002, this source contributes approximately 37% of Michigan's total air emissions (Figure 18). Other major anthropogenic sources are the use and disposal of mercury-containing products, metal processing, and cement manufacturing. When scrap metal containing mercury switches is melted down for reuse, mercury can be released into the air or leached into the water at metal recycling facilities. Mercury is also released to inland water bodies through wastewater treatment plants (WWTP). Mercury-containing amalgam used in some dental fillings is one of the primary sources of mercury in wastewater

(MDEQ, 2008a). Mercury can also be found in regulated storm water effluent and in biosolids applied to the land. In 2008, the MDEQ documented at least 3,000 sites where ongoing mercury contamination was occurring, from industrial applications such as former chlor-alkali processes, cement kiln dust, manufactured gas plants, petroleum refineries, mining, and concrete and manufacturing plants (MDEQ, 2008a). It should be noted that the estimate for natural gas combustion in 2002 was an over-estimate; current emissions are much less than 1% of the emissions inventory (MPCA, personal communication).

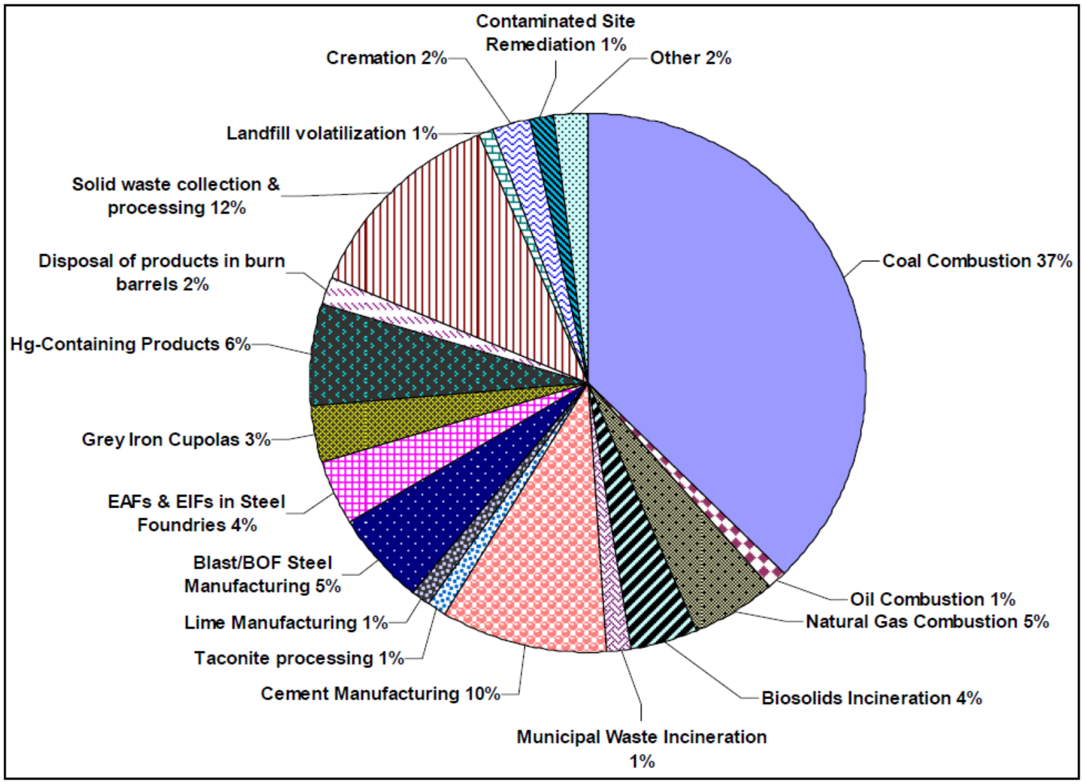


Figure 18. 2002 Estimates of Anthropogenic Mercury Air Emissions in Michigan by Source Category.
EAFs: electric arc furnaces; EIFs: electric induction furnaces. (Source: MDEQ, 2008a)

The locations of permitted mercury air sources in Michigan for 2002 are identified in Figure 19 and the reported mercury emissions (in lbs) for 2002 are identified in Figure 20.

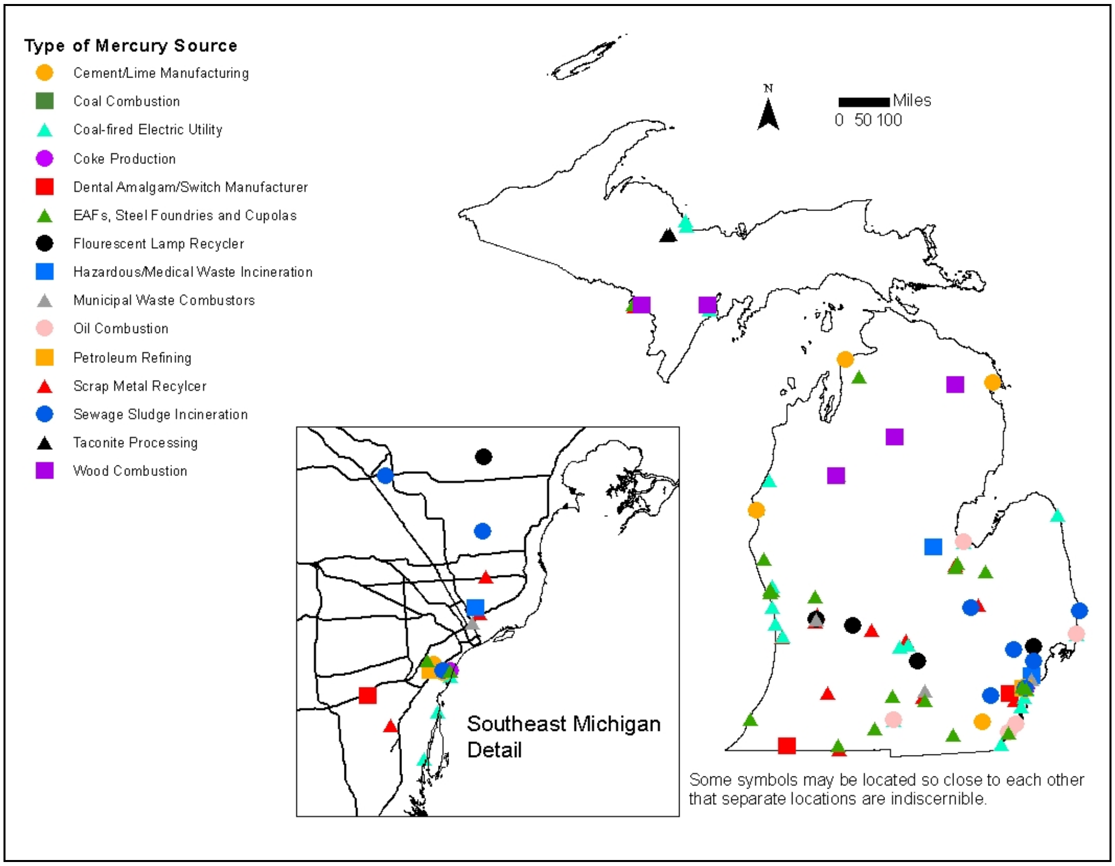


Figure 19. Permitted Air Sources of Mercury by Type of Facility.
(Data Source: MDEQ, 2008a)

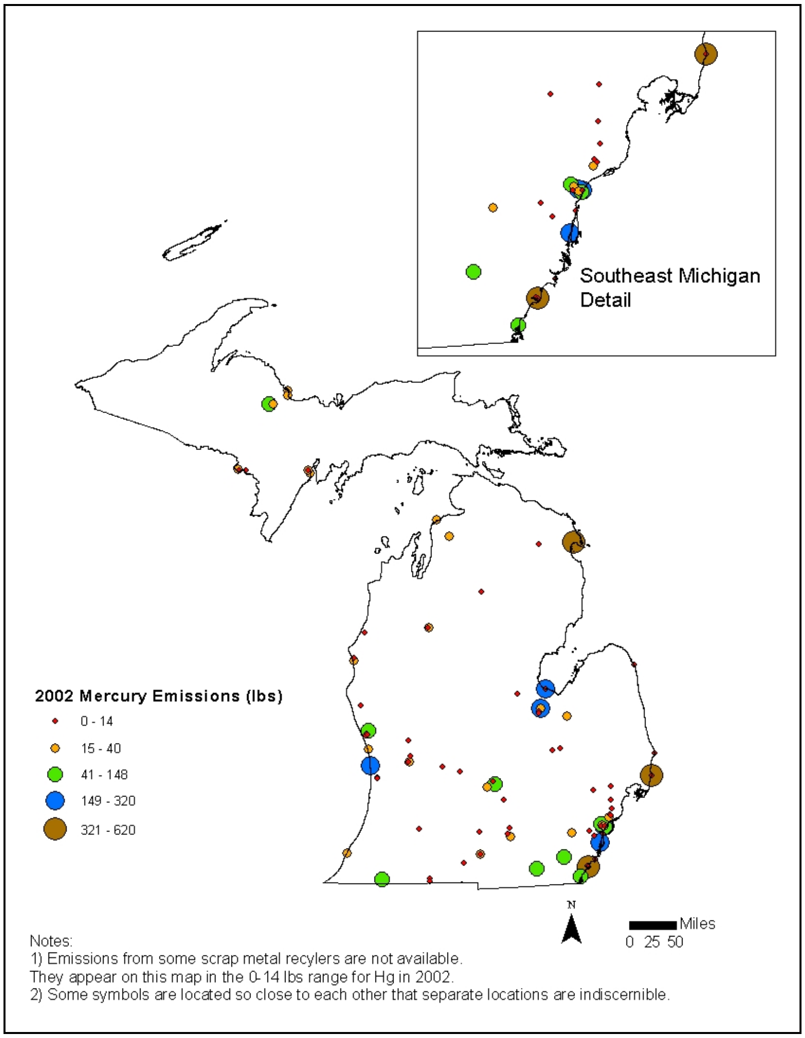


Figure 20. Annual Permitted Mercury Air Emissions for 2002.
(Data source: MDEQ, 2008a)

5.2 COMPILATION OF SOURCE DATA

All readily available information describing sources of mercury released to the environment was compiled including point sources (e.g., National Pollutant Discharge Elimination System (NPDES) permitted storm water and wastewater dischargers), nonpoint sources (NPS) (e.g., atmospheric deposition), and sites of environmental contamination (e.g., Superfund and AOCs). Sources for these data are summarized in Table 7. In addition to environmental data, geographic datasets were also obtained to understand the spatial variation in mercury impairment, and other relevant contributing factors such as land cover (Table 8).

Table 7. Datasets Used for Mercury Source Analysis.

Description of Data	Data Source
NPDES Permitted Discharges of Mercury to Inland Water Bodies (2012)	MDEQ
Mercury Emissions to the Air (2002)	MDEQ
Atmospheric Deposition of Mercury to Michigan	REMSAD Model (USEPA, 2012)
Location of Superfund Sites where Mercury is a Contaminant of Concern	MDEQ
Location of AOCs where Mercury is a Contaminant of Concern	https://www.epa.gov/great-lakes-aocs

Table 8. Geographic Datasets Obtained.

Description of Data	Type of Dataset	Source
Ecoregion boundaries for the state of Michigan.	Ecoregion Boundaries	Michigan Center for Geographic Information (MCGI), 2011[9]
Streams and Rivers (lines) from version 10a of the Michigan Geographic Framework dataset.	Hydrography	MCGI, 2011
Lakes and Rivers (polygons) from version 10a of the Michigan Geographic Framework dataset.	Hydrography	MCGI, 2011
Lake polygons for the state of Michigan.	Hydrography	MCGI, 2011
Lake contour data for lakes managed for recreational boating access.	Hydrography	MCGI, 2011
Polygons representing the boundaries of cities in Michigan.	Political	MCGI, 2011
Polygons representing the boundaries of counties in Michigan.	Political	MCGI, 2011
Polygons representing Michigan village boundaries.	Political	MCGI, 2011
2006 National Land Cover data for the entire State of Michigan.	Land Cover	Multi-Resolution Land Characteristics Consortium, 2006
High resolution NHD data for the State of Michigan.	Hydrography	USGS, 2011[10]
High resolution NHD data for the State of Michigan: HUC boundaries.	Watershed Boundaries	USGS, 2011
Assessment Unit IDs.	Hydrography	MCGI, 2011
Impaired water body segments.	Hydrography	MDEQ
EDUs.	Ecoregion Boundaries	Kendra Cheruvelil (Michigan State University)[11]

5.2.1 Data Gap Analysis

After compiling the appropriate databases, 2 data gaps were identified: (1) mining source discharges to water from both current mining operations and abandoned mines that could release mercury to the environment; and (2) specific loads or concentrations of mercury from

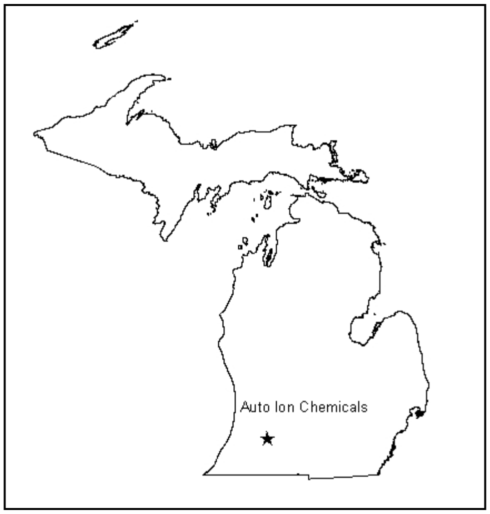
[9] Data were obtained from the MCGI's Web site http://gis-michigan.opendata.arcgis.com/ in April 2011.
[10] Data were obtained from the NHD Web site ftp://nhdftp.usgs.gov/DataSets/Staged/States/FileGDB/HighResolution/ in April 2011.
[11] Data were obtained via e-mail from Kendra Cheruvelil to Kat Ridolfi on August 10, 2011.

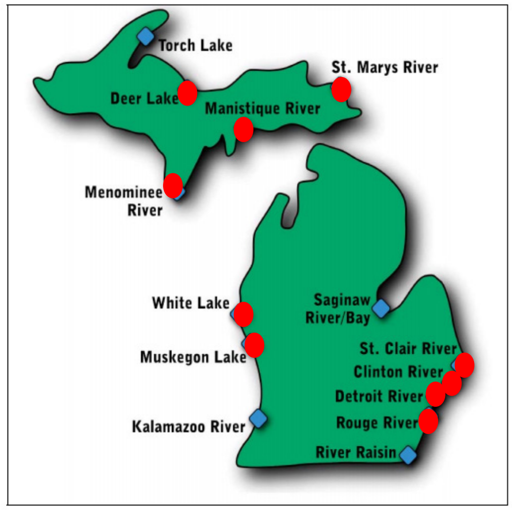
legacy point sources. To fill the data gap from currently operating mines, NPDES discharge data were reviewed, and the mercury load from this source was recorded and included in the point source mercury load. Based on a lack of available mercury data for release of mercury from abandoned mines and legacy point sources, it was determined that no further effort would be expended to fill these two data gaps.

5.2.2 NPS of Mercury

Diffuse, or NPS, of mercury consist mostly of atmospheric deposition, groundwater, land-applied biosolids, and storm water runoff from the landscape. Biosolids are defined as solid, semisolid, or liquid residues generated during primary, secondary, or advanced treatment of domestic sanitary sewage (MDEQ, 2008a). Mercury that enters a WWTP is concentrated in biosolids during treatment and disposed of by land spreading. Some of the land-applied mercury may, over time, volatilize to the atmosphere, which can then be deposited into lakes and streams, methylated, and ingested by fish, eventually reaching wildlife and humans through the food chain. Diffuse storm water runoff is considered to be minimal, compared to other sources. In addition, the primary source of mercury in diffuse storm water is assumed to be the atmosphere, so any reductions to atmospheric sources will address nonpoint storm water as well. Mercury-contaminated groundwater originates from contaminated sites such as Superfund sites and AOCs, which are in the process of being addressed by separate cleanup plans.

The location of Superfund sites and AOCs impacted by mercury are shown in Figure 21. Some of the mercury-impaired water bodies in Michigan are influenced by legacy mercury from these locations, and therefore are not included in this TMDL. Water bodies influenced by legacy sites that have cleanup plans in place are expected to meet the TMDL target once the cleanup plan is complete and the reductions described in this TMDL are met. These water bodies will be placed under the 4b category in Michigan's Integrated Report until such time that monitoring reflects the waters are in compliance with the WQS. Category 4b is intended for water bodies with a pollution control program in place that is expected to solve the pollution problems, such as Superfund and AOC cleanup plans.





a) Auto Ion Superfund Site. b) AOCs in Michigan[12]

Figure 21. Location of Legacy Mercury-Polluted Sites in Michigan.
(AOCs impacted by mercury are indicated by red dots).

5.2.3 Point Sources of Mercury to Water

Point sources of mercury consist of NPDES-permitted discharges to surface water. Examples include discharges from WWTPs, industrial manufacturing facilities, power plants, Superfund cleanup sites, and municipal storm water. Similar to nonpoint storm water runoff, the primary source of mercury in permitted municipal storm water is atmospheric deposition. There are approximately 229 individual NPDES permits in Michigan that contain mercury limits and/or low level monitoring requirements. For the development of Michigan's statewide mercury TMDL, only those discharges to inland waters were evaluated. There were 139 NPDES permitted facilities that discharged to inland receiving waters in 2012 with a mercury limit. The list of permitted facilities includes WWTPs, power plants, auto parts manufacturers, landfills, and other permitted dischargers (Table 9). In 2012, the total annual NPDES-permitted mercury load to waters addressed under this TMDL was 39.3 kg (86.6 lbs), with WWTPs, power plants, and steel manufacturing facilities comprising the majority of the load. A detailed list of NPDES-permitted point sources that discharge mercury (based on 2012 data) to inland waters is provided in Appendix B.

[12] Source: MDEQ, 2010b. Strategy for Delisting Michigan's Great Lakes Areas of Concern https://www.michigan.gov/-/media/Project/Websites/egle/Documents/Programs/WRD/AOC/delisting-strategy.pdf. On Oct. 30, 2014, the USEPA announced that Deer Lake had been removed from the binational list of AOCs.

Table 9. NPDES-Permitted Dischargers of Mercury to Inland Water Bodies.
(Data Source: MDEQ)

Type of Discharge	# Facilities	Annual NPDES-Permitted Mercury Load (lbs/yr)	Annual NPDES-Permitted Mercury Load (kg/yr)
Auto Parts Manufacturers	3	0.017	0.008
Landfills	3	0.035	0.016
Mining-related	4	0.498	0.226
Paper Mills	6	2.90	1.31
Power Plants	9	17.2	7.80
Other[1]	4	0.059	0.027
Steel Manufacturers	2	20.7	9.41
WWTPs	108	45.2	20.5
Total	**139**	**86.6**	**39.3**

[1] Includes Biofuel, Glass Manufacturing, Scrap Metal Recycling, Ott-Story Cleanup

5.2.4 Mercury Permitting Strategy for Point Sources

The MDEQ, Water Resources Division, developed a Mercury Permitting Strategy in February 2000 that established a multiple discharger variance (MDV) for mercury consistent with R 323.1103, Variances, of the Part 4 Rules. The rule allows for a variance from a WQS that is the basis for a water quality-based effluent limit in an NPDES permit where various conditions prevent the attainment of WQS. However, it is important to note that an MDV is only a temporary measure and does not take the place of a WQS. The need for a mercury variance became apparent when it was determined, through the implementation of a lower analytical quantification level for mercury in 1999, that the majority of ambient waters sampled for mercury, as well as most NPDES permitted discharges, exceeded the mercury WQS of 1.3 ng/L. The WQS of 1.3 ng/L, developed to protect wildlife, also ensures protection of human health and aquatic life. To address potential widespread noncompliance with the mercury WQS in NPDES permits, a Mercury Permitting Strategy, including an MDV consistent with the requirements of the variance rule (R 323.1103(9)), was developed.

Establishment of an MDV requires inclusion in the NPDES permit of an effluent limitation that represents a level currently achievable (LCA) by the permittee, consistent with R 323.1103(6), and implementation of a Pollutant Minimization Program (PMP) that furthers efforts to meet the mercury WQS of 1.3 ng/L. The February 2000 Strategy included a statewide LCA of 30 ng/L, based primarily on effluent data from the state of Maine. A May 2004 update to the February 2000 Strategy lowered the statewide LCA to 10 ng/L as it was determined that mercury concentrations in most Michigan NPDES-permitted discharges were significantly less than 30 ng/L. As a result of a 2007 lawsuit filed by the National Wildlife Federation on behalf of the Lone Tree Council questioning the legality of the statewide 10 ng/L LCA, the MDEQ established Policy and Procedure WB-016 for developing discharge-specific LCAs (MDEQ, 2008c). The MDEQ Policy and Procedure WB-016 was revised in 2011, updating the process by which discharge-specific LCAs are calculated in the MDEQ Policy and Procedure WRD-004 (MDEQ, 2011). The revision included incorporating the mercury monitoring frequency into the site-specific LCA calculation for those datasets with 10 or greater representative data points. The total annual NPDES-permitted mercury load identified in Table 9 is based on the sum of the mercury loads that are calculated from either the individual LCA for a facility or the 1.3 ng/L

WQS if a discharge of mercury is meeting the WQS. The individual authorized facility flows found in Appendix B.

6 TMDL DEVELOPMENT

A TMDL calculates the maximum amount of a pollutant allowed to enter a water body so that the water body will meet WQS for that particular pollutant (in this case, mercury). The TMDL allocates the maximum allowable load to point sources (Waste Load Allocation [WLA]), and NPS (Load Allocation [LA]), which include both anthropogenic and natural background sources of the pollutant. TMDLs must also include a margin of safety (MOS) to account for uncertainty in the relationship between pollutant loading and the receiving water body, and account for seasonal variations.

The TMDL is typically defined by the equation:

$$\text{TMDL (LC)} = \Sigma \text{LA} + \Sigma \text{WLA} + \text{MOS} \qquad \textbf{(2)}$$

Where

TMDL = total maximum daily load (i.e., the loading capacity (LC) of the receiving water)
ΣLA = sum of all load allocation for NPS
ΣWLA = sum of all waste load allocation for point sources
MOS = Margin of safety

The process to determine the TMDL includes:

1) Determine the LC of the receiving water(s) (i.e., the maximum pollutant load that the water body can assimilate and attain WQS)
2) Allocate this LC among the three categories shown in Equation 2.

Equation 3 is used to calculate the TMDL using the existing combined load of mercury from point and NPS, defined as the "total source load" (TSL) and the RF:

$$\text{TMDL} = \text{TSL}^* (1\text{-RF}) \qquad \textbf{(3)}$$

Where TMDL is an annual load (kg/yr); TSL is the total source load during the baseline year of 2001 (including atmospheric deposition and NPDES-permitted discharges of mercury); and RF is the reduction factor. The RF is based on the reductions needed to achieve target fish mercury concentrations (see Equation 1 in Section 4.5). An annual load is the most appropriate way to express this mercury TMDL because the goal is to address long-term mercury bioaccumulation, rather than track short-term effects. Consistent with the Northeast U.S. and Minnesota mercury TMDLs, a daily load can be estimated by dividing the annual load by 365 (MPCA, 2007; NEIWPCC, 2007) (Equation 4).

$$\text{TMDL (kg/day)} = [\text{TMDL (kg/year)}]/365 \qquad \textbf{(4)}$$

6.1 BASELINE MERCURY LOAD

As explained above, the TSL is the sum of the existing combined point and NPS loads of mercury for the baseline year (Equation 5). The year 2001 was used as the baseline year, and for calculating reductions based on the availability of the modeling results from REMSAD (Section 4.2). A 2002 emissions inventory baseline will be used to track reduction progress because the MDEQ does not have a 2001 emissions inventory for mercury and it is likely that the deposition values did not change significantly between 2001 and 2002. The TSL was calculated for 2001 as follows:

$$TSL = PSL + NPSL \quad \textbf{(5)}$$

where PSL is the point source load and NPSL is the nonpoint source load.

6.1.1 Baseline NPS Load

The NPSL includes contributions from natural (NNPSL) and anthropogenic sources (ANPSL) of mercury deposition.

$$NPSL = NNPSL + ANPSL \quad \textbf{(6)}$$

The Minnesota Mercury TMDL assumed that mercury deposition is 30% natural and 70% anthropogenic in origin (MPCA, 2007). These proportions were based on an inferred preindustrial deposition rate of 3.7 $\mu g/m^2$ relative to the total atmospheric deposition of 12.5 $\mu g/m^2$ for Minnesota in 1990. The preanthropogenic deposition of 3.7 $\mu g/m^2$ used in the Minnesota TMDL was also consistent with the value of 3.1 $\mu g/m^2$ inferred from a Lake Michigan study, showing consistency between different venues of research (Rossmann, 2010). The atmospheric deposition rate for Michigan in 2001 is 18.6 $\mu g/m^2$ based on REMSAD modeling results. The differences in atmospheric deposition rates between Minnesota (12.5 $\mu g/m^2$) and Michigan (18.6 $\mu g/m^2$) result in a higher anthropogenic percentage for Michigan than Minnesota. Therefore, using the same inferred preindustrial deposition rate of 3.7 $\mu g/m^2$ for the Michigan TMDL, mercury deposition is assumed to be 20% natural and 80% anthropogenic (since 3.7 $\mu g/m^2$ is 20% of 18.6 $\mu g/m^2$).

6.1.2 Baseline Point Source Load

The PSL consists of regulated wastewater and storm water discharges (including permitted Municipal Separate Storm Sewer System discharges). Storm water regulated under the NPDES storm water program (i.e., Phase I and Phase II) is traditionally considered to be a point source. However, information from NPDES-regulated storm water discharges is not detailed enough to estimate mercury loadings for specific outfalls. Since loading to storm water is primarily from atmospheric sources, the storm water load is implicitly included in the NPSL. Michigan has a well-developed program to address and control storm water pollution through the implementation of best management practices as required by the Clean Water Act. Any mercury in storm water that is not addressed by reductions in atmospheric sources implemented in accordance with this TMDL will be addressed by state municipal and industrial storm water permit regulations.

The PSL was estimated based on the sum of mercury loads calculated from either the individual LCA for a facility, or the WQS of 1.3 ng/L if a discharge of mercury was meeting WQS (Table 9) as described in Section 5.2.3. The NPDES-permitted facilities and the individual authorized facility flows used to calculate the PSL can be found in Appendix B.

6.1.3 Baseline TSL

The 2001 TSL is considered to be the sum of the PSL and NPSL. Because the only significant NPS of mercury is from atmospheric deposition, the NPSL is equal to the atmospheric load of mercury for 2001 provided by the REMSAD Model. Based on these calculations, the baseline TSL is 2,773 kg/yr (Table 10). The PSL is 1.4% of the TSL (Table 9).

Table 10. TSL for Mercury Baseline Year 2001.

Portion of TSL	Units	Statewide
Point Source Load (NPDES permitted discharge) [Table 9]	kg/yr	39.3
Nonpoint Source Load (atmospheric deposition) [Table 6]	kg/yr	2,734
*Natural Nonpoint Source Load (NNPSL = 0.2 * NPSL)*	*kg/yr*	*547*
Anthropogenic Nonpoint Source Load (ANPSL = NPSL - NNPSL)	*kg/yr*	*2,187*
TSL	kg/yr	2,773

6.2 TMDL CALCULATION

The TSL described in Section 6.1 and RF described in Section 4.5, are used to define the TMDL by applying the RF to the TSL, as shown in Equation 7:

$$\begin{aligned} TMDL &= TSL \times (1-RF) \\ TMDL &= 2{,}773 \times (1 - 0.6542) \\ TMDL &= 959 \end{aligned} \quad \textbf{(7)}$$

Inserting TSL (2,773) and RF (65.42%) into Equation 7 yields a TMDL of 959 kg/yr. The daily equivalent load equals the annual load divided by 365, or 2.6 kg/day. This is the daily allowable load of mercury (including both anthropogenic and natural sources) that, over time, is expected to result in meeting the fish tissue target for mercury of 0.35 mg/kg, and attaining WQS.

6.3 WLA

The WLA is defined as the portion of the LC allocated to NPDES-permitted point sources that are listed in Appendix B and covered by the statewide mercury TMDL. The WLA is equal to the sum of the authorized design flows for facilities listed in Appendix B (3,075 million gallons per day), multiplied by the WQS of 1.3 ng/L, which is equal to an annual aggregate WLA of 5.51 kg/yr. In addition, a reserve capacity of 10% of the WLA, or 0.5 kg/yr has been added to the WLA of 5.5 kg/yr, which resulted in a final aggregate WLA of 6.0 kg/yr (Table 11) for those NPDES-permitted facilities covered under the statewide mercury TMDL. The addition of the reserve capacity will allow for permitting of new discharges of mercury that must meet the WQS of 1.3 ng/L. Existing discharges of mercury will be covered under the existing MDV approach. As stated in Section 5.2.3., establishment of the MDV requires inclusion in the NPDES permit of an effluent limitation that represents an LCA by the permittee, consistent with R 323.1103(6), and implementation of a PMP that furthers efforts to meet the mercury WQS of 1.3 ng/L. Implementation of PMPs will continue to be required for all NPDES-permitted mercury discharges, and will ensure that permittees move towards meeting the WQS. This approach will lead to the reduction of the PSL from 39.3 kg/yr to 6.0 kg/yr.

Table 11. Mercury WLA.

Portion of TMDL Calculation	Annual Result
LC (TMDL)	959 kg/yr
WLA	6.0 kg/yr

6.4 LA

The LA for NPS is calculated by subtracting the WLA from the LC. The average annual LA for mercury is equal to 953 kg/yr.

$$LA = LC - WLA \qquad \textbf{(8)}$$
$$LA = 959\ kg/yr - 6.0\ kg/yr$$
$$LA = 953\ kg/yr$$

The LA includes both natural (NLA) and anthropogenic (ALA) load allocations. Since natural sources cannot be controlled, NLA is set at the same level as NNPSL, which is 547 kg/yr. Therefore, the remaining 406 kg/yr is allocated as an anthropogenic load (Table 12).

Table 12. Mercury LA.

Portion of Load Allocation	Annual Result
Load Allocation	953 kg/yr
Natural Load Allocation (NLA = NNPSL) Table 10	*547 kg/yr*
Anthropogenic load allocation (ALA = LA – NLA)	*406 kg/yr*

Table 13 provides a summary of the individual components of the TMDL.

Table 13. Summary of TMDL Components.

TMDL Components	Units	Statewide
Target Level and RF		
Target Fish Mercury Concentration (Fish Tissue Residue Value) [Equation 7]	mg/kg	0.35
Current Mercury Concentration for Standard Length Northern Pike [Figure 15]	mg/kg	1.012
RF	65%	
Mercury Load for Baseline Year 2001		
Point Source Load (39 kg/yr ÷ 365) [Table 9]	kg/day	0.11
Nonpoint Source Load (REMSAD Model) (2,734 kg/yr ÷ 365) [Table 6]	kg/day	7.49
TSL [Table 10]	kg/day	7.60
Final TMDL		
Margin of Safety	Implicit	
WLA (6 kg/yr ÷ 365) [Table 11]	kg/day	0.016
Load Allocation (includes natural and anthropogenic sources) (953 kg/yr ÷ 365) [Equation 8]	kg/day	2.61
Mercury Load Allocation for In-State and Out-of-State Deposition Sources		
In-State Contribution to LA (anthropogenic) (40 kg/yr ÷ 365) [Table 14]	kg/day	0.11
Out-of-State Contribution to LA (natural and anthropogenic) ((953 – 40 kg/yr) ÷ 365)	kg/day	2.50
Necessary Reduction from Anthropogenic Emission Sources (40 kg ÷ 213 kg from Table 6) ~ 19% (100% - 19% = 81%)		81%

Michigan's load reduction goal can be translated to emission reduction goals based on the 2002 baseline year for emissions and 2001 baseline year for deposition load. As shown in Table 6, Michigan's in-state contribution of mercury deposition for the baseline year of 2001 is 213 kg/yr determined from the REMSAD Model. The RF was determined in Section 4.5, and is the percentage by which the 90th percentile fish tissue mercury concentration for a 24-inch northern pike would need to be reduced to attain the 0.35 mg/kg fish tissue mercury residue value, statewide. The RF calculated was 65%; this same RF can be applied to atmospheric deposition based on the assumption that there is a linear load-response relationship between fish tissue, atmospheric deposition, and mercury emissions.

The REMSAD Model estimated atmospheric deposition of mercury load (NPSL) to Michigan at 2,734 kg/yr (Table 6). The PSL (NPDES-permitted discharges in Table 9) was calculated to be 39.3 kg/yr. The TSL of mercury for 2001 was therefore calculated to be 2,773 kg/yr by summing the NPSL and the PSL. When the RF (1-0.6542) is applied to the TSL, the resulting value is 959 kg/yr, and represents, over time, the annual TMDL load of mercury expected to result in meeting the fish tissue residue value for mercury of 0.35 mg/kg (Equation 7).

Subtracting the WLA of 6 kg/yr from the annual TMDL load of 959 kg/yr results in an LA of 953 kg/yr (Equation 8). The LA includes both natural (NLA) and anthropogenic (ALA) load allocations (Table 12). Since the MDEQ does not have control over natural emissions, all load reductions must come from anthropogenic sources. Therefore, the LA of 953 kg/yr must be further reduced by subtracting out the NLA. The percent of atmospheric mercury deposition that is attributed to natural sources is 20% and equates to 547 kg/yr (Table 10). Therefore, removing the natural component (547 kg/yr) from the LA (953 kg/yr) results in an ALA of 406 kg/yr (Table 12).

Additionally, not all contributions to mercury deposition originate from Michigan. In-state sources, which are 100% anthropogenic, make up 7.8% of the state's total atmospheric mercury load (Table 6) and 9.75% (7.8%/80%) of anthropogenic mercury deposition (Table 14).

Applying this percentage to the ALA of mercury (0.0975 x 406 kg/yr) results in 39.56 kg/yr or approximately 40 kg/yr that is considered Michigan's anthropogenic goal of atmospheric deposition to Michigan's inland water bodies (Table 14).

Table 14. LAs for In-State and Out-of-State Anthropogenic Sources of Mercury Deposition.

Portion of LA	Atmospheric Mercury Load Annual Result
Proportion of deposition due to out-of-state anthropogenic sources Section 6.1.1	80%
Michigan's fraction of anthropogenic sources (7.8% from Table 6 ÷80%)	9.75%
In-state contribution to LA [0.0975*ALA from Table 12]	40 kg/yr
Out-of-state contribution to LA [(1-0.0975)*ALA]	366 kg/yr

From Table 6, the Michigan baseline contribution of atmospheric mercury deposition was 213 kg/yr. Since Michigan's atmospheric deposition goal of 40 kg/yr is 19% of the baseline value (213 kg/yr), there must be an 81% reduction in anthropogenic deposition to meet the "in-state" LA of 40 kg/yr. The same degree of reduction (81%) in "out-of-state" anthropogenic sources contributing to Michigan deposition is necessary to meet the overall 65% reduction goal.

Because tracking in-state reductions will be based on 2002 estimated emissions, the reduction goal in emissions for Michigan is 81% of the 2002 emissions levels, or 622 kg/yr (Table 15).

Table 15. Summary of Baseline and Target Mercury Emissions from Michigan In-State Anthropogenic Sources.

Category	Unit	Atmospheric Mercury Emissions
2002 Estimated Emissions	kg/yr	3,272
Target Reduction Rate in Michigan's Anthropogenic Emissions		81%
Target Emissions (2002 emissions * [1- 0.81 reduction])	kg/yr	622

The researchers who conducted the deposition modeling as part of the U of M study also estimated deposition reduction scenarios based on data that were modeled using the CMAQ Model. This included (1) a scenario based on a 90% reduction in total mercury emission from Michigan's coal-fired electric generating units and (2) an 82% reduction in total mercury emissions from all other sources within the state of Michigan (the prior draft TMDL estimated an 82% rather than an 81% reduction estimated in the final TMDL). These reduction scenarios resulted in significant reductions in deposition, primarily in the urban areas of Detroit and Flint of up to almost 40% specifically for dry deposition. The rest of the state had an estimated deposition decrease of approximately 8%, highlighting the need for emission reductions beyond Michigan's borders (Marsik et al., 2014).

6.5 MOS

The MOS is a required part of the TMDL to account for technical uncertainties such as model predictions, analysis of technical data, and the relationship between pollutant loading and receiving water quality. The MOS can be either explicit (e.g., stated as an additional percentage load reduction) or implicit (i.e., conservative assumptions in the TMDL calculations or overall approach) in the calculations of the TMDL, or a combination of the two. For this mercury TMDL, the MOS is implicit due to the use of northern pike as the target fish species. Northern pike are large piscivorous fish, meaning that they occupy a high position in the food web and have the highest fish tissue mercury concentrations in the state relative to other species (Table 2). Therefore, most fish in the state will have a lower fish tissue mercury concentration. Calculating the TMDL based on this high average mercury tissue concentration incorporates an implicit MOS into the analysis.

6.6 CRITICAL CONDITIONS AND SEASONAL VARIATION

TMDLs are required to consider seasonal variations and critical environmental conditions [40 CFR §130.7(c)(1)]. Mercury concentrations in the atmosphere and water column can fluctuate seasonally. However, accumulation of mercury in fish tissue over time masks any seasonal variations. Due to the extremely slow response time of water and fish concentrations to changes in atmospheric loads, essentially no seasonal variation occurs in fish mercury concentrations due to seasonal variations in atmospheric concentrations. The mercury concentration in the fish represents an integration of all temporal variation up to the time of sample collection. Variability among fish because of differences in size, diet, habitat, and other undefined factors are expected to be greater than seasonal variability (MPCA, 2007).

There are critical conditions in the sense that certain water bodies and fish species are more likely to bioaccumulate mercury because of individual water chemistry characteristics, and the biochemistry of individual fish species. This aspect of critical conditions has been addressed in this TMDL by using a top predator fish species known to have high bioaccumulation potential. Thus, the critical conditions are assumed to be adequately addressed in the existing analysis.

7 REASONABLE ASSURANCE AND IMPLEMENTATION

This TMDL assumes that atmospheric NPS mercury loads to Michigan waters will be reduced in the future. TMDLs that allow for reductions from sources for which an NPDES permit is not required should provide a reasonable assurance that the controls will be implemented and maintained. In addition, controls of mercury through issuances of NPDES permits will continue into the future. As discussed below, there are numerous state and federal regulations and other activities that are expected to reduce future mercury concentrations to levels consistent with the TMDL.

7.1 CLEANUP OF LEGACY SOURCES

Formal cleanup plans are in place at several sites influenced by legacy sources. The Great Lakes Legacy Act was signed into law in 2002, and authorized by Congress in 2008, to provide funding to clean up contaminated sediment in AOCs in the Great Lakes region[13]. While these AOCs focus primarily on Great Lakes waters not considered by the TMDL, many of the cleanup plans extend inland to waters covered by this TMDL.

The Comprehensive Environmental Response, Compensation and Liability Act of 1980, provides a federal "Superfund" to clean up uncontrolled or abandoned hazardous waste sites. Sites eligible for long-term cleanup action under the Superfund program are located on the National Priorities List, a list of environmentally contaminated sites, published by the USEPA, which pose an immediate or significant public health threat to the local community. Michigan currently has 65 sites on the National Priorities List[14], many of which include contamination by mercury. Cleanup plans are in place for all of these sites. The remediation of these legacy sites will provide two mechanisms to help achieve the TMDL target. First, these cleanups will allow designated uses to be attained at legacy sites after atmospheric mercury emissions are reduced to levels outlined by the TMDL. Second, these cleanups will contribute to the necessary reduction of local atmospheric mercury emissions, as volatilization of mercury from legacy sites can serve as a source of mercury to the atmosphere.

7.2 VOLUNTARY ACTIVITIES

7.2.1 Michigan Mercury Strategy

The MDEQ Mercury Strategy staff report (MDEQ, 2008a), has a goal to eliminate anthropogenic mercury use and emissions within the state of Michigan. The Strategy contains over 60 recommendations, and 10 recommendations are prioritized. One of the priority recommendations is to implement a mercury TMDL, which this document fulfills.

The Mercury Strategy for Michigan summarizes pollution prevention programs and their successes. Between 1994 and 2007, these programs successfully recovered 19,000 lbs (8,618 kg) of mercury that might have otherwise been released to the environment. Programs that recovered the largest share of mercury during this time period include the Groundwater Stewardship Clean Sweep Program (nearly 8,000 lbs), Detroit Edison Hg P2 Initiative (2,745 lbs), Consumers Energy (1,488 lbs), and a joint agency Dental Mercury Removal Program (1,400 lbs) (MDEQ, 2008a).

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[13] https://www.epa.gov/great-lakes-legacy-act
[14] https://www.epa.gov/superfund/national-priorities-list-npl-sites-state

The MDEQ received a USEPA GLRI grant to implement the Strategy in 2010, which contains further voluntary and regulatory activities to reduce mercury in Michigan.

Funded by the GLRI grant, the MDEQ worked cooperatively with the MDHHS on efforts to reduce mercury use and educate the public on proper ways to dispose of mercury-containing items and help distribute the newly developed fish consumption guidelines to various stakeholders.[15] Mercury spill workshops have been funded in the state and public service announcements have been developed to help educate Michigan's citizens on the concern with mercury. Public service announcements have been developed primarily by the MDHHS and Michigan State University via the USEPA grant to implement the statewide MDEQ Mercury Strategy and aired at the Michigan Secretary of State offices from October 2012 to early November 2012. These video clips are available on the MDHHS's YouTube channel.[16]

These videos describe the need for mercury-containing items to be removed from homes, concern for spills, costs and exposure, and fish consumption. There will be more videos developed in the future regarding the mercury fish consumption guidelines and compact fluorescent light bulbs. The MDEQ developed brochures on mercury-containing products that are shared with local and state health departments. The brochures include:

- Common Mercury Items
- Mercury Spills
- Recycle Mercury – Get Rid of Mercury Safely
- Eliminate Mercury in Schools
- Mercury and Plumbing
- Mercury and Electrical Trades
- Mercury and Heating, Ventilation, and Air Conditioning Work
- Mercury and Antiques
- Mercury and Renovation Work

A final report outlining the efforts made in Michigan to implement the USEPA GLRI grant was submitted to the USEPA on September 30, 2015 (MDEQ, 2015b). Highlights of the final report include: a summary of the dental amalgam separators installed in the state, a summary of mercury-containing automobile switches collected, mercury-containing thermostats collected, fact sheets developed in partnership with the MDHHS, a report on the other mercury-containing items collected both at Michigan's clean sweep sites and through a contract with U.S. Ecology.

7.2.2 Regional/National Efforts

The Great Lakes Regional Collaboration served as a foundation for the development of the GLRI and has continued the successful efforts of the Great Lakes Binational Toxics Strategy. Under the Great Lakes Regional Collaboration, 2 specific mercury strategies were developed for the Great Lakes region, 1 on products and the other on emissions[17].

Continued implementation of these strategies will help to meet the goals of this TMDL. Additionally, the Great Lakes Water Quality Agreement led to the Lake Superior Binational

[15] Go to Michigan.gov/mercury to view this information and click on "more on mercury".
[16] Go to www.youtube.com/michigandch to view the videos
[17] Both of these strategies are available at: https://www.glrc.us/

Program that is serving as a demonstration area where no point source discharge of any persistent toxic chemicals will be permitted. The USEPA, Environment Canada, and the states (MDEQ) work together on this binational program to virtually eliminate toxics (mercury). This binational program has a goal of 100% reduction (for mercury) by 2020 as compared to a 1990 baseline[18]. The Lake Superior Lake-Wide Management Plan is the vehicle used for implementation. Remediation plans and implementation for the AOCs contaminated with mercury will further mercury reduction efforts at these contaminated sites[19].

7.2.3 Mercury Monitoring

The MDEQ participates with the Environmental Council of States (ECOS) Quicksilver Caucus on various national mercury issues that address air, water, waste, and pollution prevention. MDEQ staff have worked on a variety of reports including the most recent national mercury compendium. The Quicksilver Caucus works together to further reduce mercury releases to the environment by developing educational materials, policy documents, and has ongoing dialogue with the USEPA on mercury regulations[20].

The GLRI funding also allowed the MDEQ to be a member of the Interstate Mercury Education and Reduction Clearinghouse, which provides critical information on use and compliance reporting with various legislation in the nation[21].

Currently, several programs are in place to monitor mercury in the state including the following summarized from the MDEQ (2008a):

- Tri-State Mercury Monitoring Project (Michigan, Minnesota, and Wisconsin)
- MDEQ, Air Quality Division (AQD), mercury emission inventory data monitoring
- Michigan Water Chemistry Monitoring Project
- Surface Water Monitoring (data stored in MiSWIM)
- Michigan Wildlife Contaminant Monitoring Project
- Michigan FCMP

7.3 REGULATORY ACTIVITIES

7.3.1 Air - State

Michigan utilizes its air quality regulatory programs to reduce mercury released from air emission sources through the air permitting process. In 1994, the MDEQ, AQD, implemented the air toxics rules to address the release of toxic air pollutants. Any new or modified source of mercury emissions must go through a best available control technology for toxics review (commonly called T-BACT) and are required to demonstrate the maximum degree of mercury emission reduction reasonably achievable taking into account energy, environmental, economic impacts, and other costs. New or modified sources of mercury emissions must also go through a health-based screening review that uses modeling of source emissions to predict the ambient

[18] Go to *(The link provided was broken and has been removed)* to view progress on the efforts of this program.

[19] Go to *(The link provided was broken and has been removed)* for information on remediation plans.

[20] Go to https://www.michigan.gov/-/media/Project/Websites/egle/Documents/Programs/AQD/toxics/presentation-2012-10-mercury-activities.pdf for information on the Quicksilver Caucus.

[21] (*The link provided was broken and has been removed)*

impact of a toxic chemical. Predicted ambient impacts can be no greater than health-based screening levels and indirect exposure can also be considered[22] These rules do not apply to existing sources.

The MDEQ developed air pollution control rules addressing mercury emissions from coal-fired electric generating units. The rules under Part 15, Emission Limitations and Prohibitions - Mercury, went into effect October 16, 2009. These rules were later modified to mirror the federal Mercury and Air Toxics Standards[23] (MATS) discussed in Section 7.3.2. The rule language states Part 15 will not be implemented if the MATS requirements are in effect.

The MDEQ, AQD, can also incorporate special conditions in air permits to reduce mercury emissions. Examples include metal shredders that must document the removal of mercury-containing switches, electric arc furnaces that must test for mercury, and other new and/or modified sources in Michigan that have required air emission limits and stack tests. From 2006 to 2011, 223,452 automobile mercury-containing switches were recycled in Michigan[24].

7.3.2 Air - Federal

The federal MATS require electric generating units to limit their emissions of mercury and other toxic air pollutants. The rules apply to coal and oil-fired electric generating units with a capacity of 25 megawatts or greater. With the MATS compliance date of April 15, 2016, facilities throughout the nation have prepared for the regulation of mercury. As a result, many units have been retrofitted with mercury control, others have been switched to lower emitting fuels, and a number will be retired from service. In Michigan, it is anticipated over 10 units will be retired and a number will have converted from coal to natural gas burning units. Preliminary calculations show an estimated reduction of 400 pounds of mercury per year from the retirements. Further reductions are expected as part of the MATS compliance activities.

Section 112 of the federal Clean Air Act requires the USEPA to regulate emissions of toxic air pollutants, including mercury, from a published list of industrial sources referred to as "source categories." As required under the Clean Air Act, the USEPA has developed a list of source categories that must meet control technology requirements for these toxic air pollutants. The USEPA is required to develop regulations (rules or standards) for all industries that emit one or more of the pollutants in significant quantities. Table 3-2 in the Mercury Strategy (MDEQ, 2008a) lists the USEPA's promulgated standards under 40 CFR and their potential impact on mercury reduction. Under 112(l) of the Clean Air Act, the USEPA has approved delegation to the MDEQ to implement these standards for major sources. After promulgating rules for iron and steel foundries, electric arc furnaces, and aluminum, copper, and other nonferrous foundries specifically to address mercury emissions, the MDEQ, AQD, sought and received delegation from the USEPA. The MDEQ, AQD, had previously taken delegation for 4 area source rules: chromium electroplating, Portland cement manufacturing, secondary aluminum production, and publicly owned treatment works.

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[22] *(The link provided was broken and has been removed)*

[23] See https://www.epa.gov/mats

[24] See http://elvsolutions.org/?page_id=114%22 and https://www.epa.gov/mercury for more information on switch recycling programs.

Finally, for cement plants in Michigan, the MDEQ will be following the federal National Emissions Standards for Hazardous Air Pollutants rule to control mercury emissions from Portland cement plants.

7.3.3 Michigan Legislation to Reduce Mercury Waste

Michigan has passed several pieces of legislation to reduce the use and release of mercury into the air and waters of the state. These include:

- Dental Mercury Amalgam Separators (Public Act 503, 2008)

A portion of the GLRI grant funds were provided to the Michigan Dental Association in 2011 to offer incentives to dental offices to install dental amalgam separators to comply with Michigan's regulations. Dentists were required to comply with the 2008 regulation and install dental amalgam separators by December 31, 2013. As of September 2014, dentists in Michigan have installed 1,262 dental amalgam separators, and have assisted in removing and recycling 2,524 pounds of waste amalgam or 1,262 pounds of mercury each year since 2011.

- Mercury-Free State Purchasing (Public Act 193, 2008)
- Mercury Phase Out in Schools (Public Act 376, 2000)

Significant efforts have been made by the MDEQ, MDHHS, and the Michigan Department of Education to educate schools about this legislation. Several letters have been sent to Michigan principals, science teachers, library/media specialists, and superintendents since the law became final. Fact sheets and educational CDs were developed and distributed to the schools. Additionally, the MDEQ participated with the USEPA on collecting mercury from schools in several cities.

- Mercury Thermometer Sales Ban (Public Act 578, 2002)
- Mercury Thermostat Sales Ban (Public Act 492, 2006)

Collection increased with expanded outreach due to a grant from the MDEQ to Michigan Energy Options. Currently, there are 220 mercury thermostat collection sites throughout Michigan. Since project startup in 2009, approximately 65,800 thermostats have been collected, which resulted in approximately 489 lbs of mercury recycled (Michigan Energy Options, 2014).

From 2010 to 2013, the MDEQ funded the Michigan Energy Options to conduct outreach and participation by heating, ventilation, and air conditioning contractors; wholesalers; and retailers in the thermostat recycling program. A Web site has been created under the grant to provide contractors and residents information on how to find a collection location[25].

- Mercury Blood Pressure Device Sales/Use Ban (Public Act 493, 2006)
- Mercury-containing Medical Devices Sales Ban (Public Act 494, 2006)
- Trash Burning Restrictions (Public Act 102 of 2012)

Michigan passed legislation (signed April 19, 2012) to limit the uncontrolled open burning of household waste. Open burning of household waste that may contain mercury is not allowed.

[25] See *(The link provided was broken and has been removed)* to find a recycling location near you.

The list of banned materials includes plastic, rubber, foam, chemically treated wood, textiles, electronics, chemicals, and hazardous materials. The law went into effect October 16, 2012[26].

7.3.4 NPDES Program Control of Mercury to Surface Waters

R 323.1103(9) of the Part 4 Rules provides the conditions under which an MDV may be granted. Specifically, an MDV may be granted due to widespread WQS compliance issues, including the presence of ubiquitous pollutants or naturally high background levels of pollutants in a watershed. Due to ubiquitous mercury concentrations in many of Michigan's inland waters at levels exceeding the WQS, as described above, many facilities are not able to comply with the mercury WQS in a cost-effective manner. Michigan has concluded that, in general, end-of-pipe treatment for mercury is not the most cost-effective method to achieve the WQS. Michigan supports the USEPA's position that pollution prevention and waste minimization programs for mercury should be the first steps in restoring water quality before considering extraordinary treatment alternatives.

R 323.1201 of the Part 8 Rules, Water Quality-Based Effluent Limit Development for Toxic Substances, of Act 451, describes Michigan's commitment to the use of pollution prevention, source control, and other waste minimization programs to achieve compliance with low water quality-based effluent limits. As such, each NPDES permit that includes a variance for mercury contains a requirement to develop and implement a PMP for mercury, with the goal of attaining the WQS.

[26] See *(The link provided was broken and has been removed)* for more information on trash burning restrictions.

8 POST-TMDL MONITORING

Post-TMDL monitoring consists of collecting and analyzing data to evaluate how well a TMDL is working towards attaining the WQS. This monitoring can assist in determining whether planned control actions are sufficient to attain the WQS, or whether further measures need to be implemented. This section describes monitoring to measure mercury concentrations in fish, water, land, and air to track TMDL effectiveness.

8.1 MDEQ MONITORING

Three of the 4 monitoring goals described in the MDEQ's Water Quality Monitoring Strategy directly align with post-TMDL monitoring goals. These are: (1) assess the current status and condition of waters of the state and determine whether the WQS are being met; (2) measure spatial and temporal water quality trends; and (3) evaluate the effectiveness of water quality prevention and protection programs. These goals are assessed through evaluation of a variety of data. For post-TMDL monitoring, the MDEQ should analyze fish tissue and water samples for mercury (MDEQ, 2017a). In addition to the programs described below, mercury data collected through the Michigan Wildlife Contaminant Monitoring Program may also be used to assess trends.

8.1.1 FCMP

The FCMP is part of the MDEQ's comprehensive water quality monitoring strategy. Edible portion fish contaminant data are used by the MDHHS to develop the Michigan Fish Advisory MDEQ, 2017b). Whole fish data are used to track contaminant trends. Approximately 20 to 30 lakes in Michigan are sampled annually for mercury in fish tissue with specific locations driven by programmatic need and sample availability. Both the edible and whole fish sampling programs will generate data that can be used to evaluate TMDL effectiveness.

8.1.2 WCMP

The MDEQ's WCMP includes mercury analysis and is comprised of the following elements that are relevant to post-TMDL monitoring:

- Fixed station trend (31 tributaries)
- A probability sampling component
- Watershed surveys (consistent with the five-year basin cycle)
- Minimally impacted sites
- Special studies (TMDLs, NPS issues, statewide mercury assessment, etc.)

The probability sampling component of the WCMP will continue as long as funding is available and will be used to determine the statistical status and trend of mercury in Michigan waters. Fixed station trend and minimally-impacted site monitoring were discontinued after 2013, but some sites could be resampled in the future to evaluate if mercury levels are declining. Data collected as part of the 5-year rotating watershed surveys are summarized in watershed reports. Data collected through special studies are summarized in individual reports and prepared for each applicable water body for consideration during the state's 2-year integrated report cycling (MDEQ, 2012a).

8.1.3 NPDES Monitoring Program

As part of the NPDES permitting program, mercury is monitored in effluent and reported for those NPDES-permitted facilities that have effluent mercury limits and/or reporting requirements. These monitoring data are provided by the facilities to the MDEQ, and are used to determine whether the facilities are in compliance with permit limitations. Typically, effluent monitoring for mercury ranges from monthly to quarterly, depending on a facility's current effluent concentration. Generally, those facilities with a mercury effluent concentration greater than 5 ng/L are required to monitor effluent on a monthly basis. Facilities with an effluent concentration of less than 5 ng/L are required to monitor effluent quarterly. In addition, effluent monitoring is required as part of the PMP requirement of NPDES permits that contain mercury effluent limitations.

8.2 ATMOSPHERIC EMISSION INVENTORY

Because mercury is a naturally occurring element, mercury can be released into the atmosphere by both natural and anthropogenic sources as well as re-emissions from previously emitted and deposited emissions. An emission inventory was developed in 2002 by the MDEQ, AQD, for anthropogenic emissions of mercury located within the state of Michigan. An emission inventory compiles emissions from point, area, and mobile sources. Point sources include specific industrial facilities such as a steel mill or power plant; area sources include small pollution sources like fluorescent light bulb crushers, which do not emit sufficient quantities of criteria pollutants to require reporting to the annual point source inventory; and mobile sources include on-road vehicular traffic and off-road equipment such as agricultural and construction equipment.

The mercury emission inventory is a specialized product that utilizes various pieces of information to compile the best estimate of the mercury that is emitted into Michigan's air over one year. The methods may include stack test data measuring actual emissions, short- or long-term, or calculations using published emission factors. The USEPA defines an emission factor as, "the relationship between the amount of pollution produced and the amount of raw material processed or number of product units produced." Emission factors are used when actual emission data are not available. Typically, the factors are averages of all available quality assured data, and are given a rating depending on the data quality or number of sources utilized. Most of the estimates for facilities used in the MDEQ, AQD, mercury emissions inventory utilized emission factors. Although the number of facilities using stack test data is small, these sources emit a disproportionately large share of Michigan's mercury emissions. For area source emission calculations, mass balance calculations are typically used to estimate these emissions using a mercury flow model developed by the Swedish government and updated by the USEPA.

A baseline emission inventory for 2002 is being utilized for the statewide mercury TMDL because it was the most comprehensive mercury emissions inventory developed to date by the MDEQ, AQD. A mercury emission inventory has been developed for 2005, 2008, and 2011. Beginning in 2019, mercury emission inventories are planned for 2014 and 2017. These emission inventories will be utilized to track the success of meeting the goal set in this statewide mercury TMDL of reducing air emissions by 81% from the 2002 baseline. The air emission goal is 1,371 lbs/yr.

Progress toward this goal will be tracked by the MDEQ, AQD, through the development of mercury emission inventories every 3 years.

8.3 ATMOSPHERIC MERCURY MONITORING

Long-term atmospheric mercury deposition is no longer routinely monitored in Michigan. From 1995 to 2005 the U of M, Air Quality Laboratory, measured mercury deposition during precipitation events at 3 sites throughout the state (Figure 4; MDEQ, 2008a). Though funding for this program has ceased, it provides a good baseline from which to compare future atmospheric wet deposition, if funding becomes available. Another network, the Mercury Deposition Network, is a national network that, depending on funding, periodically monitors for weekly composite mercury wet deposition in the state. Currently 2 mercury deposition network sites are being funded in the state of Michigan by the USEPA.[27] There is also a Canadian Atmospheric Mercury Measurement Network[28].

8.4 BIOSOLIDS MONITORING

The Part 24 Rules, Land Application of Biosolids, of Act 451, establish standards consisting of general requirements, pollutant limits, management practices, and operational requirements for the beneficial land application of biosolids. In compliance with the provisions of the Part 24 Rules, biosolids generated by facilities that hold individual "certificates of coverage" are authorized to be land applied in accordance with the limitations, monitoring requirements, and other conditions set forth in the NPDES general permit, General Permit Authorizing Land Application of Biosolids[29]. Biosolids are typically sampled and analyzed according to the amount generated, with the frequency of sampling ranging from monthly to annually (Table 16). Since 1981 the concentration of mercury in biosolids has decreased (Figure 22).

Table 16. Frequency of Monitoring for Biosolids Based on Tonnage.
(Source: R 323.2412(33) of the Part 24 Rules)

Dry Tons (per year)	Frequency
Greater than zero, but less than 319	Annually (Once per year)
Equal to or greater than 319, but less than 1,650	Quarterly (4 times per year)
Equal to or greater than 1,650, but less than 16,500	Once per 60 days (6 times per year)
Equal to or greater than 16,500	Monthly (12 times per year)

[27] Go to *(The link provided was broken and has been removed)* for more information.
[28] Go to https://www.canada.ca/en/environment-climate-change/services/air-pollution/monitoring-networks-data/canadian-air-precipitation.html for more information.
[29] Go to https://www.michigan.gov/egle/about/Organization/Water-Resources/npdes/general-permits

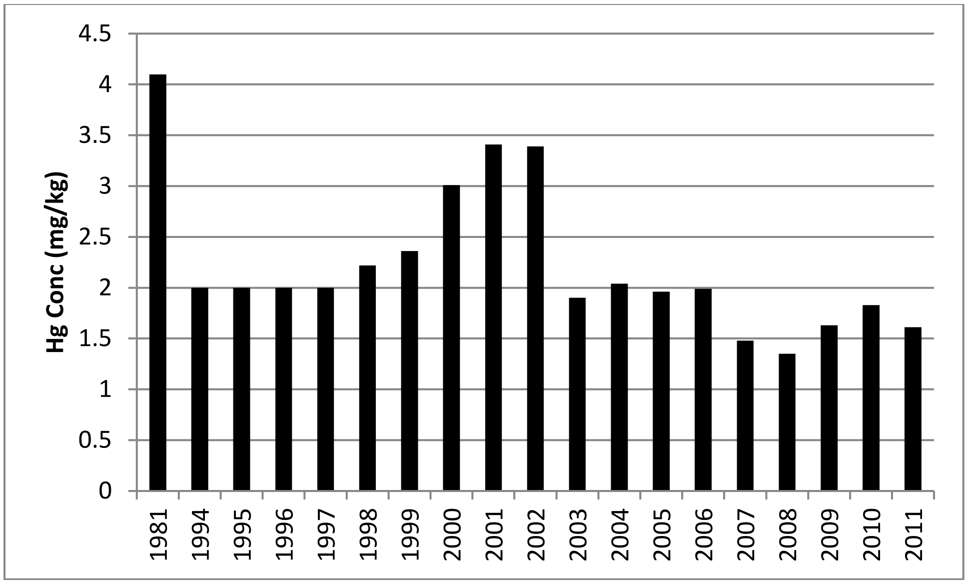

Figure 22. Mercury Concentration in Biosolids 1981-2011.
(Data Source: MDEQ)

8.5 NEW MONITORING AND ASSESSMENT DATA

As part of Michigan's monitoring and assessment programs, new data, including fish tissue data, are continually being collected. New fish tissue data are typically considered during the state's 2-year integrated reporting cycle pursuant to Sections 305(b) and 303(d) of the Clean Water Act. Outcomes are based on the Assessment Methodology described for that Integrated Report cycle:

8.6 TMDL REVISION

Revision of this TMDL document is expected to occur during Michigan's Integrated Report process. The MDEQ will identify new waters to add to the mercury TMDL and those no longer covered by the TMDL should data indicate WQS are met. Public review of the updated list of mercury impaired waters will be requested concurrent with the public notice of the Michigan Integrated Report. The revised list will be included in each subsequent Integrated Report following the USEPA's approval of this TMDL.

The public notice will note if the state is making any revisions (after consulting with the USEPA) to the TMDL targets, RFs, LCs, allocations, reduction goals, or any other element established in this TMDL. Only those elements being changed will be subject to public review. These items cannot be changed without consulting with the USEPA. TMDLs that are reviewed and approved by the USEPA can be viewed on the MDEQ Web site.[30]

[30] Go to https://www.michigan.gov/egle/about/Organization/Water-Resources/tmdls for information on where to find USEPA-approved TMDLs.

9 REFERENCES

Atkeson, T., D. Axelrad, C. Pollman, and G. Keeler. 2003. Integrated Summary Integrating Atmospheric Mercury Deposition and Aquatic Cycling in the Florida Everglades: An approach for conducting a Total Maximum Daily Load analysis for an atmospherically derived pollutant. Prepared for the USEPA, October, 2002, Revised October 2003. *(The link provided was broken and has been removed)*

Beckvar, N., J. Field, S. Salazar, and R. Hoff. 1996. Contaminants in Aquatic Habitats at Hazardous Waste Sites: Mercury. NOAA Technical Memorandum NOS ORCA 100. National Oceanic and Atmospheric Administration. Seattle, Washington.

Berlin, M., R. K. Zalups, and B. A. Fowler. 2007. "Mercury," in Handbook on the Toxicology of Metals, G. F. Nordberg, B. A. Fowler, M. Nordberg, and L. T. Friberg, Eds., chapter 33, Elsevier, New York, NY, USA, 3rd edition.

Bloom, N.S., G.A. Gill, S. Cappellino, C. Dobbs, L. McShea, C. Driscoll, R.P. Mason, and J.Rudd. 1999. Speciation and cycling of mercury in Lavaca Bay, Texas, sediments. Environmental Science and Technology 33:7–13.

Brigham, M.E., M. B. Sandheinrich, Gay, D. A. Maki, R. P. Krabbenhoft, D.P. and J. G. Wiener. 2014. Lacustrine responses to decreasing wet mercury deposition rates—results from a case study in northern Minnesota: Environmental Science and Technology. 6115-6123.

Butler, T.J., Cohen, M.D., Vermeylen, V.M., Likens, G.E., Schmeltz, D., and Artz, R.S. 2008. Regional precipitation mercury trends in the eastern USA, 1998–2005: Declines in the Northeast and Midwest, no trend in the Southeast. Atmos. Environ. 42 (2008) 1582-1592.

Chadwick, S.P., C. L. Babiarz, J. P. Hurley, and D.E. Armstrong. 2012. Importance of hypolimnetic cycling in aging of "new" mercury in a northern temperate lake. Science of the Total Environment Available online 19 November 2012. http://dx.doi.org/10.1016/j.scitotenv.2012.10.069

Choi, S.C. and R. Bartha. 1993. Cobalamin-mediated mercury methylation by Desulfovibrio desulfuricans LS. Applied Environmental Microbiology 59:290-295.

Compeau, G.C. and R. Bartha. 1985. Sulfate-reducing bacteria—principal methylators of mercury in anoxic estuarine sediment. Applied and Environmental Microbiology 50:498-502.

Davis, J., D. Yee, J. Collins, S. Schwarzbach, and S. Luoma. 2003. Potential for increased mercury accumulation in the estuary food web. San Francisco Estuary and Watershed Science.

Depew, D.C., N. Basu, N.M. Burgess, L.M. Campbell, D.C. Evers, K.A. Grasman, and A.M. Scheuhammer. 2012. Derivation of screening benchmarks for dietary methylmercury exposure for the common loon (Gavia immer): Rationale for use in ecological risk assessment. Environmental Toxicology and Chemistry. 31(10): 2399-2407.

Devereux, R., M.R. Winfrey, J. Winfrey, and D.A. Stahl. 1996. Depth profile of sulfate-reducing bacterial ribosomal RNA and mercury methylation in an estuarine sediment. FEMS Microbiology Ecology 700: 1-9.

Drevnick, P.E., Engstrom, D.R., Driscoll, C.T., Swain, E.B., Balogh, S.J.Kammen, N.C., Rossmann, R. 2012. Spatial and temporal patterns of mercury accumulation in lacustrine sediments across the Laurentian Great Lakes region. Environmental Pollution, 161, 252-260.

Evers, D.C., L. Savoy, C.R. DeSorbo, D. Yates, W. Hanson, K.M Taylor, L. Siegel, J.H. Cooley, M. Bank, A. Major, K. Munney, H.S. Vogel, N. Schoch, M. Ppkras, W. Goodale, and J. Fair. 2008a. Adverse effects from environmental mercury loads on breeding common loons. Ecotoxicology 17:69-81.

Evers, D.C., J.G. Wiener, C.T. Driscoll, D.A. Gay, N. Basu, B.A. Monson, K.F. Lambert, H.A. Morrison, J.T. Morgan, K.A. Williams, and A.G. Soehl. 2011. Great Lakes Mercury Connections: The Extent and Effects of Mercury Pollution in the Great Lakes Region. Biodiversity Research Institute. Gorham, Maine. Report BRI 2011-18.
(The link provided was broken and has been removed)

Evers, D.C., J.A. Schmutz, N. Basu, C.R. DeSorba, J. Fair, C.E. Gray, J.D. Paruk, M. Perkins, K. Regan, B.D. Uher-Koch, and K.G. Wright. 2014. Historic and contemporary mercury exposure and potential risk to yellow-billed loon (Gavia adamsii) breeding in Alaska and Canada. Waterbirds 37(sp 1):147-159.

FCMP. 2011. Fish Tissue Concentration Data Collected in Michigan Water bodies. Database received 3/29/11.

Gilmour, C.C., G.A. Gill, M.C. Stordal, and E. Spiker. 1998. Mercury methylation and sulfur cycling in the Northern Everglades. Biogeochemistry 40**:** 326–346.

Gochfeld, M. 2003. Cases of mercury exposure. Ecotoxicology and Environmental Safety 56(1):174-179

Higgins, J.V., M.T. Bryer, M.L. Khoury, and T.W. Fitzhugh. 2005. A freshwater classification approach for biodiversity conservation planning. Conservation Biology 19:432-445.

Horowitz HM, Jacob DJ, Amos HM, Streets DG, Sunderland EM (2014) Historical Mercury Releases from commercial products: Global environmental implications. Environ Sci Technol 48(17):10242–10250.
ttp://acmg.seas.harvard.edu/publications/2014/Horowitz_et_al_2014_EST.pdf

Keeler, G.J. and J.T. Dvonch. 2005. Atmospheric mercury: a decade of observations in the great lakes. In: Pirrone, N. and Mahaffey, K., editors. Dynamics of mercury pollution on regional and global scales: atmospheric processes and human exposures around the world. Springer. 611-632.

Keeler, G.J., Landis, M.S., Norris, G.A., Christianson, E.M., and Dvonch, J.T. 2006. Sources of mercury wet deposition in eastern Ohio, USA. Environ. Sci. Technol. 40:5874-5881.

Klasing, S. and R. Brodberg. 2008. Development of Fish Contaminant Goals and Advisory Tissue Levels for Common contaminants in California Sport fish: Chlordane, DDTs, Dieldrin, Methylmercury, PCBs, Selenium, and Toxaphene. Office of Environmental Health Hazard Assessment: Sacramento, CA.

Knauer, D., G. Pelkola, S. Casey, D. Krabbenhoft and J. DeWild. 2012. The Distribution of Total and Methyl Mercury in Michigan's Upper Peninsula Lakes. MI/DEQ/WRD-12/002.

Landis, M.S., Vette, A.F. and Keeler, G.J. 2002. Atmospheric mercury in the Lake Michigan basin: influence of the Chicago/Gary urban area. Environ. Sci. Technol. 36:4508-4517.

Liu, B., Keeler, G.J., Dvonch, J.T., Barres, J.A.,. Lynam, M.M., Marsik, F.J. and Morgan, J.T. 2010. Urban-rural differences in atmospheric mercury speciation. Atmos. Environ. 44 (2010) 2013-2023.

Marsik, F.J, S. Sillman, T.J. Dvonch, J. Barres, G. Chensue, and Z. Ebenstein. 2014. Project Final Report. Deposition Modeling in Support of the Michigan Mercury TMDL. USEPA Great Lakes Restoration Initiative. Grant Number GL-00E00605.
(The link provided was broken and has been removed)

Mast, M.A. and D.P. Krabbenhoft. 2010. Comparison of Mercury in Water, Bottom Sediment, and Zooplankton in Two Front Range Reservoirs in Colorado, 2008-2009. Scientific Investigations Report; 2010-5037.

MCGI. 2011. Michigan Geographic Data Library. Accessed April 2011 at
(The link provided was broken and has been removed.)

MDHHS. 2013. Michigan Fish Consumption Advisory Program Guidance Document. Date Final: September 17, 2014, Version 2.0.
(The link provided was broken and has been removed.)

MDEQ. 2008a. Mercury Strategy Staff Report: MDEQ's Current Status and Recommended Future Activities Toward the Goal of Eliminating Anthropogenic Mercury Use and Releases in Michigan.
(The link provided was broken and has been removed.)

MDEQ. 2008b. Michigan Fish Contaminant Monitoring Program, 2008 Annual Report. MDEQ Staff Report #MI/DEQ/WB-09/044. Michigan.gov/-/media/Project/Websites/egle/Documents/Programs/WRD/GLWARM/Monitoring-Lake/fcmp-2008-report.pdf

MDEQ. 2008c. Policy and Procedure WB-016. Calculation of Level Currently Achievable for Mercury in Proposed National Pollutant Discharge Elimination System Permits.

MDEQ. 2010b. Strategy for Delisting Michigan's Great Lakes Areas of Concern https://www.michigan.gov/-/media/Project/Websites/egle/Documents/Programs/WRD/AOC/delisting-strategy.pdf

MDEQ. 2011. Policy and Procedure WRD-004. Calculation of Level Currently Achievable for Mercury in Proposed National Pollutant Discharge Elimination System Permits.

MDEQ. 2012a. Water Quality and Pollution Control in Michigan 2012 Sections 303(d), 305(b), and 314 Integrated Report. MDEQ Staff Report #MI/DEQ/WB-12/001.

MDEQ. 2012c. Impact of Fish Fillet Hg Concentration of 0.35 mg/kg on Wildlife. Authored by Dennis Bush, Water Toxics Units, Water Resources Division, MDEQ. February 1, 2012.

MDEQ. 2015a. Fish Contaminant Monitoring Report, A Summary of Edible Portion Sampling Effort and Analytical Results, December 2014. MDEQ Staff Report #MI/DEQ/WRD-15/001.

MDEQ. 2015b. Michigan Mercury Strategies Final Report GLRI Grant GL00E00468-4 October 1, 2010 – September 30, 2015.

MDEQ. 2017a. Michigan Water Quality Monitoring Strategy Update, January 2017. Michigan.gov/-/media/Project/Websites/egle/Documents/Programs/WRD/GLWARM/Monitoring-Watershed/strategy-update-2017.pdf

MDEQ. 2017b. Fish Contaminant Monitoring Program 2016 Annual Report: A Summary of Edible Portion Sampling Effort and Analytical Results With Recommendations For Updates to the Michigan Department of Health and Human Services Eat Safe Fish Guide. June 2017. MDEQ Staff Report # MI/DEQ/WRD-17/015.

Michigan Energy Options. 2014. Mercury Thermostat Recycling Program. MDEQ Grant #430355-09.

MPCA. 2007. Minnesota Statewide Mercury Total Maximum Daily Load. Minnesota Pollution Control Agency. March 27, 2007. *(The link provided was broken and has been removed.)*

Multi-Resolution Land Characteristics Consortium. 2006. National Land Cover Dataset. *(The link provided was broken and has been removed.)* Accessed 2011.

NEIWPCC. 2007. Northeast Regional Mercury Total Maximum Daily Load. October 24, 2007.

Prestbo, E.M. and D.A. Gay. 2009. Wet deposition of mercury in the U.S. and Canada, 1996-2005: Results and analysis of the NADP mercury deposition network. Atmos. Environ. 43 (2009) 4223-4233.

Quicksilver Caucus – Environmental Council of States. 2012. Third Compendium of States' Mercury Activities. October 2012. https://www.michigan.gov/-/media/Project/Websites/egle/Documents/Programs/AQD/toxics/presentation-2012-10-mercury-activities.pdf.

Regnell, O., G. Ewald, and O. Sangfoizs. 1996. Methylmercury production in freshwater microcosms affected by dissolved oxygen levels: Role of cobalamin, and microbial community composition. Canadian Journal of Fisheries and Aquatic Science 53: 1535-1545.

Risch, M.R., Gay, D.A., Fowler, K.K., Keeler, G.J., Backus, S.M., Blanchard, P., Barres, J.A. and Dvonch, J.T. 2012. Spatial patterns and temporal trends in mercury concentrations, precipitation depths, and mercury wet deposition in the North American Great Lakes region, 2002-2008. Environ. Pollut. 161 (2012) 261-271.

Risch, MR., Kenski, D.M., Gay, D.A. 2014. A Great Lakes Mercury Monitoring Network: evaluation and design. Atmospheric Environment 85:109-122.

Rossmann, R. 2010. Protocol to Reconstruct Historical Contaminant Loading to Large Lakes: The Lake Michigan Sediment Record of Mercury. Environmental Science and Technology. 2010, 44 (3), pp 935–940

Slotton, D.G., J.E. Reuter, and C.R. Goldman. 1995. Mercury uptake patterns of biota in a seasonally anoxic northern California reservoir. Water, Air, and Soil Pollution 80:841-850.

Sznopek, J.L. and T.G. Goonan. 2000. The materials flow of mercury in the economics of the United States and the world. Denver, CO. USGS Circular 1197. http://pubs.usgs.gov/circ/2000/c1197/

USEPA. 1991. Technical Support Document for Water Quality-Based Toxics Control. EPA Report #505/2-90-001. *(The link provided was broken and has been removed)*

USEPA. 2000. Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health (2000). EPA-822-B-00-004. Office of Water. Washington, D.C. October.

USEPA. 2001a. Water Quality Criterion for the Protection of Human Health: Methylmercury. Office of Science and Technology, Office of Water. EPA-823-R-01-001.

USEPA. 2001b. Mercury Maps: A Quantitative Spatial Link Between Air Deposition and Fish Tissue. Peer Reviewed Final Report. EPA-823-R-01-009.

USEPA. 2001c. Great Lakes Water Quality Initiative Criteria Documents for the Protection of Wildlife. Office of Science and Technology, Office of Water. EPA-820-B-94-008.

USEPA. 2006. Binational Toxics Strategy Mercury Progress Report.
(The link provided was broken and has been removed.)

USEPA. 2008a. TMDLs Where Mercury Loadings Are Predominantly From Air Deposition. Accessed October 24, 2012. https://www.epa.gov/tmdl/tmdls-where-mercury-loadings-are-predominantly-air-deposition

USEPA. 2008b. Model-Based Analysis and Tracking of Airborne Mercury Emissions to Assist in Watershed Planning. Watershed Branch, Office of Wetlands, Oceans, and Watersheds. Washington, D.C. https://www.epa.gov/tmdl/model-based-analysis-and-tracking-airborne-mercury-emissions-assist-watershed-planning-report

USEPA. 2012. Personal communication with D. Atkinson, USEPA. April, 2012.

USEPA. 2013. A Long-Term Vision for Assessment, Restoration, and Protection Under the Clean Water Act Section 303(d) Program. December 5, 2013.

USGS. 2011. [National Hydrography Dataset. Accessed April 2011 at ftp://nhdftp.usgs.gov/DataSets/Staged/States/FileGDB/HighResolution/

U of M, Air Quality Laboratory. 2009. Monitoring Atmospheric Mercury Species in Michigan. Prepared for the Great Lakes Protection Fund and the Great Lakes Commission.

Varricchione, J., K. Turek, and L. Schoen. In Preparation. Michigan's Water Chemistry Monitoring Program: A Report of Statewide Spatial Patterns (2005-2014) and Fixed Station Status and Trends (1998-2014). MDEQ, Surface Water Assessment Section, Water Resources Division, Lansing, MI.

Vijayaraghavan, R., Levin L., Parker, L., Yarwood, G., Streets D. 2014. Response of fish tissue mercury in a freshwater lake to local, regional, and global changes in mercury emissions. *Environ Toxicol Chem* 2014;33:1238–1247.

Watras, C.J., N.S. Bloom, R.J.M. Hudson, S. Gherini, R. Munson, S.A. Claas, K.A. Morrison, J. Hurley, J.G. Wiener, W.F. Fitzgerald, R. Mason, G. Vandal, D. Powell, R.G. Rada, L. Rislov, M. Winfrey, J. Elder, D. P. Krabbenhoft, A.W. Andren, C. Babiarz, D.B. Porcella, and J.W. Huckabee. 1994. Sources and Fates of Mercury and Methylmercury in Wisconsin Lakes. Pages 153-177 in C. J. Watras and J. W. Huckabee, editors. Mercury Pollution: Integration and Synthesis. Lewis Publishers, Palo Alto, California.

Wiener, J.G., D.P. Krabbenhoft, G.H. Heinz, and A.M. Scheuhammer. 2003. Ecotoxicology of mercury. In: Hoffman, D.J., Rattner, B.A., Burton, G.A. Jr., and J.Cairns (eds). Handbook of Ecotoxicology, 2nd ed. CRC Press, Chapter 16.

Wiener, J.G., R.A. Bodaly, S.S. Brown, M. Lucotte, M.C. Newman, D.B. Porcella, R.J. Reash, and E.B. Swain. 2007. Monitoring and evaluating trends in methylmercury accumulation in aquatic biota. Chapter 4 in R. C. Harris, D. P. Krabbenhoft, R. P. Mason, M. W. Murray, R. J. Reash, and T. Saltman (editors). Ecosystem Responses to Mercury Contamination: Indicators of Change. CRC Press/Taylor and Francis, Boca Raton, Florida. pp. 87-122.

Zhang, Y., D. J. Jacob, H. M. Horowitz, L. Chen, H. M. Amos, D. P. Krabbenhoft, F. Slemr, V. St. Louis, and E. M. Sunderland, Observed decrease in atmospheric mercury explained by global decline in anthropogenic emissions, PNAS, 2016.

APPENDIX A.
LIST OF MERCURY-IMPAIRED INLAND WATER BODIES SUBMITTED FOR APPROVAL UNDER THIS TMDL

AUID	Assessment Unit Name	Location Description	Source of Impairment
040201010109-01	Rivers/Streams in HUC 040201010109	Includes: West Branch Duck Creek	Water
040201010109-02	Rivers/Streams in HUC 040201010109	Includes: Lake Superior Coastal Tributaries	Water
040201010205-01	Rivers/Streams in HUC 040201010205	Includes: Abitosse Creek, Black River, Kallander Creek and Sunset Creek	Water
040201010205-02	Rivers/Streams in HUC 040201010205	Includes: Powder Mill Creek	Water
040201010205-03	Rivers/Streams in HUC 040201010205	Includes: Powder Mill Creek	Water
040201010301-03	POMEROY LAKE	SE of Marenisco E. of Route 525.	Fish
040201010304-03	ORMES LAKE	8 miles SE of Marenisco.	Fish
040201010306-01	Rivers/Streams in HUC 040201010306	Includes: Brotherton Creek	Water
040201010306-02	Rivers/Streams in HUC 040201010306	Includes: Little Presque Isle River, Monarch Creek, Veron Creek and Wolf Mountain Creek	Water
040201020101-02	CISCO LAKE CHAIN	West of Watersmeet, not including Thousand Island Lake	Fish
040201020101-03	THOUSAND ISLAND LAKE	SW of Watersmeet.	Fish
040201020104-02	BEATONS LAKE	Ottawa National Forest NE of Stickley.	Fish
040201020111-01	Rivers/Streams in HUC 040201020111	Includes: Cedar Creek, Farmer Creek, Junco Creek, Maple Leaf Creek, Mulligan Creek and South Branch Ontonagon River	Water
040201020201-04	DUCK LAKE	SW of Watersmeet.	Fish
040201020204-03	MARION LAKE	W. of Watersmeet.	Fish
040201020205-02	BOND FALLS FLOWAGE	Bond Falls Flowage is an impoundment in the headwaters of the Middle Br. Ontonagon River. NE of Sylvania on Rt. 2. and Watersmeet on Rt. 45.	Fish
040201020303-02	TEPEE LAKE	7 miles S. of Kenton off Forest Hwy. 16.	Fish
040201020307-04	BOB LAKE	SE of Pori and 9 miles west of the Baraga/Houghton County Line and 1 mile S. of the Ontonagon/Houghton County Line (Ottawa National Forest).	Fish
040201020404-01	Rivers/Streams in HUC 040201020404	Includes: Bingham Creek, Hendrick Creek, Knute Creek and Montgomery Creek	Water

AUID	Assessment Unit Name	Location Description	Source of Impairment
040201020404-03	LAKE GOGEBIC	Vicinity of Bergland and Lake Gogebic.	Fish
040201020407-01	Rivers/Streams in HUC 040201020407	Includes: Gleason Creek, Russell Creek, Stindt Creek, Trestle Creek, West Branch Ontonagon River, Whisky Hollow Creek and Woodpecker Creek	Water
040201020408-02	VICTORIA RESERVOIR	SW of Rockland.	Fish
040201020409-01	Rivers/Streams in HUC 040201020409	Includes: West Branch Ontonagon River, Austin Creek, East Branch Mill Creek, Gates Creek, Irish Creek, Mill Creek, Ontonagon River, Patty Creek, Plover Creek, Rockland Creek, Sandstone Creek and Sucker Creek	Water
040201020409-02	Rivers/Streams in HUC 040201020409	Includes: Unnamed Tributary to Ontonagon River	Water
040201020409-03	Rivers/Streams in HUC 040201020409	Includes: Ontonagon River	Water
040201030104-01	Rivers/Streams in HUC 040201030104	Includes: Dishinaw Creek, Silver Creek and West Branch Firesteel River	Water
040201030104-02	SUDDEN LAKE	E. of Forest Hwy. 16, S. of Rt. 38 - 19 miles west of Baraga.	Fish
040201030104-03	Rivers/Streams in HUC 040201030104	Includes: West Branch Firesteel River and Tributaries	Water
040201030303-07	Rivers/Streams in HUC 040201030303	Includes: Hammell Creek	Water
040201030304-01	TORCH LAKE	In the vicinity of the communities of Hubbell and Lake Linden.	Fish
040201030307-08	PORTAGE LAKE	Vicinity of Houghton and Hancock.	Fish
040201030401-01	Rivers/Streams in HUC 040201030401	Includes: Hills Creek upstream of Gratiot River Road to headwaters	Water
040201030401-03	Rivers/Streams in HUC 040201030401	Includes: Muggun Creek	Water
040201030401-04	Rivers/Streams in HUC 040201030401	Includes: Sevenmile Creek	Water
040201030401-05	Rivers/Streams in HUC 040201030401	Includes: Hills Creek	Water
040201030401-06	Rivers/Streams in HUC 040201030401	Includes: Various Tributaries to Lake Superior	Water
040201030403-01	Rivers/Streams in HUC 040201030403	Includes: Silver Creek and various Lake Superior Tributaries	Water

AUID	Assessment Unit Name	Location Description	Source of Impairment
040201030501-03	LAKE MEDORA	4.5 miles SW of Copper Harbor.	Fish
040201030505-01	RICE LAKE	SW of Traverse Bay on Keweenaw Peninsula.	Fish
040201040101-02	Rivers/Streams in HUC 040201040101	Includes: Tioga River	Water
040201040102-02	VERMILAC LAKE (AKA: WORM LAKE)	E. of Covington.	Fish
040201040102-03	KING LAKE	E. of Vermilac.	Fish
040201040104-02	MARTEN LAKE	Ottawa National Forest. 2 miles south of Houghton/Baraga county line.	Fish
040201040104-05	PERCH LAKE	N. of Iron River.	Fish
040201040207-04	EMILY LAKE	Mishwabic State Forest S. of Twin Lakes.	Fish
040201040207-06	SIX MILE LAKE	W. of Nisula.	Fish
040201040208-01	Rivers/Streams in HUC 040201040208	Includes: Ebers Creek	Water
040201040208-02	Rivers/Streams in HUC 040201040208	Includes: Bart Creek, North Branch Bart Creek, North Branch Otter River and Small Bear Creek	Water
040201040208-03	Rivers/Streams in HUC 040201040208	Includes: North Branch Bear Creek and South Branch Bear Creek	Water
040201040209-02	OTTER LAKE	Vicinity of Askel.	Fish
040201050101-01	Rivers/Streams in HUC 040201050101	Includes: Carp Creek, Cooper Creek and Larson Creek upstream of Ishpeming	Fish and Water
040201050101-04	Rivers/Streams in HUC 040201050101	Includes: Carp Creek from Ishpeming to Deer Lake	Fish and Water
040201050102-01	Rivers/Streams in HUC 040201050102	Includes: Carp River from Deer Lake upstream	Water
040201050102-02	Rivers/Streams in HUC 040201050102	Includes: Unnamed Tributary to the Carp River	Water
040201050105-01	Rivers/Streams in HUC 040201050105	Includes: Big Garlic River, Sawmill Creek and Wilson Creek	Water
040201050205-01	FORESTVILLE BASIN	From the Tourist Park Dam u/s to the powerhouse at the west end of the Forestville Reservoir.	Fish
040201050301-01	Rivers/Streams in HUC 040201050301	Includes: Yellow Dog River	Water
040201050301-02	Rivers/Streams in HUC 040201050301	Includes: Yellow Dog River	Water
040201050302-03	Rivers/Streams in HUC 040201050302	Includes: Yellow Dog River	Water

AUID	Assessment Unit Name	Location Description	Source of Impairment
040201050303-02	LAKE INDEPENDENCE	Vicinity of Big Bay.	Fish
040201050401-02	Rivers/Streams in HUC 040201050401	Includes: Salmon Trout River	Water
040201050606-01	Rivers/Streams in HUC 040201050606	Includes: Slate River	Water
040202010101-02	Rivers/Streams in HUC 040202010101	Includes: East Branch Chocolay River including Tributaries	Water
040202010112-01	AU TRAIN LAKE	W. of Munising.	Fish
040202010207-02	NAWAKWA LAKE	N. of Lavender Corners and Rt. 77.	Fish
040202010209-04	GRAND SABLE LAKE	Grand Sable State forest.	Fish
040202010211-02	MUSKALLONGE LAKE	18 miles E. of Grand Marais off Rt. 407 in Lake Superior State Forest.	Fish
040202010302-02	PRETTY LAKE	Reaches contained in HUC 040202010302	Fish
040202020106-01	DOLLARVILLE FLOODING	Vicinity of Dollarville and Newberry. Dollarville Flooding is an impoundment of the Tahquamenon River.	Fish
040202020106-02	Rivers/Streams in HUC 040202020106	Includes: Silver Creek and Tahquamenon River	Fish
040202020107-01	Rivers/Streams in HUC 040202020107	Includes: Sixteen Creek, Tahquamenon River and Thirtynine Creek	Fish
040202020301-01	Rivers/Streams in HUC 040202020301	Includes: Quinn Creek	Water
040202020301-02	Rivers/Streams in HUC 040202020301	Includes: Hendrie River and Naugle Creek	Water
040202020502-01	Rivers/Streams in HUC 040202020502	Includes: Gimlet Creek	Fish
040202020504-01	Rivers/Streams in HUC 040202020504	Includes: Hiawatha Creek and Tahquamenon River	Fish
040202020505-01	Rivers/Streams in HUC 040202020505	Includes: Baird Creek, Freeman Creek, Penny Creek, Popps Creek and Tahquamenon River	Fish
040202020506-01	Rivers/Streams in HUC 040202020506	Includes: Callam Creek, Linton Creek, Middle Branch Linton Creek, North Branch Linton Creek, Rose Creek, South Branch Linton Creek and Tahquamenon River	Fish
040202020507-01	Rivers/Streams in HUC 040202020507	Includes: Anchard Creek and Bowers Creek	Fish
040202020508-01	Rivers/Streams in HUC 040202020508	Includes: Lynch Creek and Tahquamenon River	Fish and Water

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040202020508-02	Rivers/Streams in HUC 040202020508	Includes: Cheney Creek	Water
040202030102-02	Rivers/Streams in HUC 040202030102	Includes: Ankodosh Creek and Bearpen Creek	Water
040202030203-01	Rivers/Streams in HUC 040202030203	Includes: West Branch Waishkey River - McMahen, Clear, White, Horseshoe, Bons, Sylvester Creeks	Water
040203000001-02	SISKIWIT LAKE	Isle Royale.	Fish
040203000001-03	ECHO LAKE	On Grand Island located offshore of the communities of Christmas and Munising.	Fish
040301060205-02	CABLE LAKE	Copper Country State Forest.	Fish
040301060307-06	SUNSET LAKE	NE of Iron River.	Fish
040301060401-01	Rivers/Streams in HUC 040301060401	Includes: Silver Creek	Water
040301060401-02	Rivers/Streams in HUC 040301060401	Includes: Edna Creek, McColman Creek, Paint River, and Unnamed Tributary to Edna Creek	Water
040301060405-02	CHICAGON LAKE	Vicinity of Chicagon.	Fish
040301060405-03	LONG LAKE	6 miles NW of Crystal Falls.	Fish
040301060405-04	LAKE EMILY	N. of Chicagon.	Fish
040301060407-03	FORTUNE LAKE (SECOND LAKE)	Vicinity of Fortune Lake.	Fish
040301060408-02	RUNKLE LAKE	East of Crystal Falls.	Fish
040301060409-02	PAINT RIVER POND	Brule Dam (NE of Florence, Wisconsin) u/s to the Paint River inlet.	Fish
040301070102-02	UNNAMED LAKE	Located SE of Crooked Lake.	Fish
040301070106-01	BEAUFORT LAKE	Vicinity of Three Lakes.	Fish
040301070108-01	Rivers/Streams in HUC 040301070108	Includes: Michigamme River	Fish
040301070109-01	Rivers/Streams in HUC 040301070109	Includes: Michigamme River and Trout Falls Creek	Fish
040301070110-01	Rivers/Streams in HUC 040301070110	Includes: Caps Creek, Gambles Creek and Michigamme River	Fish
040301070110-02	PERCH LAKE	SE of Republic.	Fish
040301070111-01	Rivers/Streams in HUC 040301070111	Includes: Michigamme River and Wilson Creek	Fish
040301070111-02	Rivers/Streams in HUC 040301070111	Includes: Michigamme River	Fish

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040301070205-01	Rivers/Streams in HUC 040301070205	Includes: Fence River, McMillan Creek and Threemile Creek	Fish
040301070302-02	Rivers/Streams in HUC 040301070302	Includes: Deer River	Fish
040301070303-01	Rivers/Streams in HUC 040301070303	Includes: Michigamme River	Fish
040301070303-02	Rivers/Streams in HUC 040301070303	Includes: Squaw Creek	Fish
040301070304-01	Rivers/Streams in HUC 040301070304	Includes: Crescent Pond Outlet and Michigamme River	Fish
040301070304-02	SILVER LAKE	6 miles NE of Channing off Rt. 95 in Copper Country State Forest).	Fish
040301070305-01	Rivers/Streams in HUC 040301070305	Includes: Clarks Creek and Michigamme River	Fish
040301070305-03	MICHIGAMME RESERVOIR	Michigamme River impoundment upstream of the Way Dam NE of Kelso Junction and Crystal Falls.	Fish
040301070305-04	Rivers/Streams in HUC 040301070305	Includes: Margeson Creek, trib to Michigamme Reservoir	Fish
040301070306-01	Rivers/Streams in HUC 040301070306	Includes: Camp Six Creek	Fish
040301070306-02	Rivers/Streams in HUC 040301070306	Includes: Clarks Creek, Kelso Creek, Kelso River, Kukura Creek and Michigamme River	Fish
040301070306-03	Rivers/Streams in HUC 040301070306	Includes: Parks Creek	Fish
040301070307-01	Rivers/Streams in HUC 040301070307	Includes: Camp Five Creek, Davison Creek, Larson Creek and Michigamme River	Fish
040301070307-02	PEAVY POND	4.0 miles u/s from Brule River confluence and east of Iron County Airport.	Fish
040301070308-01	Rivers/Streams in HUC 040301070308	Includes: Gages Creek and Michigamme River	Fish
040301080401-02	SOUTH GROVELAND POND	12 miles NE. of Iron Mountain in the Copper Country State Forest.	Fish
040301080407-01	HAMILTON LAKE	SE of Loretto.	Fish
040301080408-01	Rivers/Streams in HUC 040301080408	Includes: Black Creek and Sturgeon River	Fish
040301080408-02	HANBURY LAKE	Reaches contained in HUC 040301080408	Fish

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040301080705-01	Rivers/Streams in HUC 040301080705	Includes: Fumee Creek and Menominee River	Fish and Water
040301080705-02	FUMEE LAKE	North of Quinnesec.	Fish
040301080706-01	Rivers/Streams in HUC 040301080706	Includes: Menominee River	Fish
040301080706-02	Rivers/Streams in HUC 040301080706	Includes: White Creek and Unnamed Tributary to Menominee River	Fish
040301080707-01	Rivers/Streams in HUC 040301080707	Includes: Brandts Creek, Carlson Creek, Harter Creek, Menominee River, Mullen Creek and Seynor Creek	Fish
040301080707-02	Rivers/Streams in HUC 040301080707	Includes: Faithorn Creek	Fish
040301080708-01	Rivers/Streams in HUC 040301080708	Includes: Bird Creek, Blom Creek, DeHaas Creek, Hammond Brook and Pemene Creek	Fish
040301080710-01	Rivers/Streams in HUC 040301080710	Includes: Goodman Brook, Kading Creek and Menominee River	Fish
040301080710-02	Rivers/Streams in HUC 040301080710	Includes: Miscauna Creek	Fish
040301080711-01	CHALK HILLS IMPOUNDMENT	Chalk Hill Dam u/s to Miscauno Island.	Fish
040301080711-02	Rivers/Streams in HUC 040301080711	Includes: Menominee River, Rosebush Creek and Sawbridge Creek	Fish
040301080712-01	Rivers/Streams in HUC 040301080712	Includes: Menominee River	Fish
040301080803-01	Rivers/Streams in HUC 040301080803	Includes: Boyle Creek and Hays Creek	Water
040301080805-01	Rivers/Streams in HUC 040301080805	Includes: Hugos Brook, Little Cedar River and Little Kelley Creek	Fish
040301080902-01	Rivers/Streams in HUC 040301080902	Includes: Longrie Creek and Shakey River	Fish
040301080902-02	LONG LAKE	W. of Stephenson. Shakey Lakes County Park (Escanaba State Forest).	Fish
040301080906-01	Rivers/Streams in HUC 040301080906	Includes: Menominee River	Fish
040301080907-01	Rivers/Streams in HUC 040301080907	Includes: Harding Creek, Phillips Creek and Woods Creek	Fish
040301080908-01	Rivers/Streams in HUC 040301080908	Includes: Koss Creek and Menominee River	Fish

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040301080908-02	Rivers/Streams in HUC 040301080908	Includes: Burke Creek	Fish
040301080909-01	Rivers/Streams in HUC 040301080909	Includes: Menominee River	Fish
040301080913-01	Rivers/Streams in HUC 040301080913	Includes: Chappee Creek, Menominee River, Pine Creek and Sobiesky Creek	Fish and Water
040301080913-02	Rivers/Streams in HUC 040301080913	Includes: Menominee River	Fish and Water
040301090106-01	Rivers/Streams in HUC 040301090106	Includes: Helps Creek, Skidmore Creek, South Branch Ford River and West Branch Ford River	Water
040301090203-01	Rivers/Streams in HUC 040301090203	Includes: Tenmile Creek	Water
040301090404-01	Rivers/Streams in HUC 040301090404	Includes: Indian Creek and Wilson Creek	Water
040301090404-03	Rivers/Streams in HUC 040301090404	Includes: Alder Brook	Water
040301100101-03	ROUND LAKE	2.5 miles north of Champion, within the Escanaba River State Forest.	Fish
040301100102-01	Rivers/Streams in HUC 040301100102	Includes: Black River and Bruce Creek	Water
040301100105-02	GREENWOOD RESERVOIR	Impoundment of the Middle Branch Escanaba River.	Fish
040301100106-02	SCHWEITZER RESERVOIR	Five miles S. of Ishpeming.	Fish
040301100206-02	SHAG LAKE	Three miles SW of Gwinn and located in the headwaters of the Escanaba River watershed.	Fish
040301100303-01	Rivers/Streams in HUC 040301100303	Includes: Chynes Creek, Lindsey Creek, Little West Branch Escanaba River and Lone Pine Creek	Water
040301100308-01	Rivers/Streams in HUC 040301100308	Includes: Bichler Creek, Escanaba River and Silver Creek	Water
040301100308-02	Rivers/Streams in HUC 040301100308	Includes: Escanaba River	Fish and Water
040301100308-03	Rivers/Streams in HUC 040301100308	Includes: Escanaba River and Reno Creek	Water
040301110101-01	Rivers/Streams in HUC 040301110101	Includes: Huber Creek, McMaster Creek, Sucker Creek and West Branch Whitefish River	Water

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040301110104-01	Rivers/Streams in HUC 040301110104	Includes: Dexter Creek	Water
040301110205-01	Rivers/Streams in HUC 040301110205	Includes: Tacoosh River	Water
040301120106-01	Unassessed Rivers/Streams in HUC 040301120106	Waters only 'assessed' for Navigation, Agriculture, and Industrial Water Supply	Water
040301120201-02	ROUND LAKE	19 miles SW of Munising in the Hiawatha National Forest.	Fish
040301120204-01	Rivers/Streams in HUC 040301120204	Includes: Eighteenmile Creek, Johnson Creek and Mink Creek	Water
040301120207-01	Rivers/Streams in HUC 040301120207	Includes: Bull Run and Sturgeon River	Water
040301120207-02	Rivers/Streams in HUC 040301120207	Includes: Sturgeon River	Water
040500010104-02	COLDWATER LAKE	S. of Coldwater.	Fish
040500010111-02	RANDALL LAKE CHAIN	Vicinity NW of Coldwater.	Fish
040500010111-04	RANDALL LAKE CHAIN	Vicinity NW of Coldwater.	Fish
040500010111-07	RANDALL LAKE CHAIN	Vicinity NW of Coldwater.	Fish
040500010201-01	Rivers/Streams in HUC 040500010201	Includes: Beebe Creek and all tributaries from Impoundment upstream of Lake Pleasant Road to headwaters.	Water
040500010404-03	PALMER LAKE	Vicinity of Colon.	Fish
040500010502-07	GOURDNECK LAKE	S. of Poratge.	Fish
040500010805-02	Rivers/Streams in HUC 040500010805	Includes: Fawn River and all tributaries from Hinebaugh Drain upstream to Indiana line.	Fish
040500010806-03	Rivers/Streams in HUC 040500010806	Includes: Unnamed Tributary to Fawn River	Fish
040500010807-03	Rivers/Streams in HUC 040500010807	Includes: Fawn River	Fish
040500010808-02	KLINGER LAKE	E. of White Pigeon and W. of Sturgis.	Fish
040500010808-03	THOMPSON LAKE	4 miles NW of Sturgis.	Fish
040500010809-01	Rivers/Streams in HUC 040500010809	Includes: Fawn River and all tributaries, except Sherman Mill Creek, from St. Joseph River confluence upstream to Pickerel Lake outlet.	Fish
040500011107-01	Rivers/Streams in HUC 040500011107	Includes: Pigeon River and all tributaries in Michigan from St. Joseph River confluence upstream to Indiana stateline.	Fish

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040500011304-01	Rivers/Streams in HUC 040500011304	Includes: St Joseph River from Mill Creek upstream to Fawn River confluence, includes Black Run.	Water
040500011304-02	Rivers/Streams in HUC 040500011304	Includes: St Joseph River from Pigeon River upstream to Mill Creek	Water
040500012306-01	Rivers/Streams in HUC 040500012306	Includes: Pokagon Creek	Water
040500012503-01	RUSH LAKE	3 miles NW of Hartford.	Fish
040500012503-02	VAN AUKEN LAKE	3 miles NW of Hartford.	Fish
040500012602-01	Rivers/Streams in HUC 040500012602	Includes: Saint Joseph River and Spring Valley Drain	Water
040500012605-01	Rivers/Streams in HUC 040500012605	Includes: Pipestone Creek	Water
040500012605-02	Rivers/Streams in HUC 040500012605	Includes: Pipestone Creek	Water
040500012608-01	Rivers/Streams in HUC 040500012608	Includes: Saint Joseph River	Water
040500012608-02	Rivers/Streams in HUC 040500012608	Includes: Saint Joseph River	Water
040500012608-03	Rivers/Streams in HUC 040500012608	Includes: BIG MEADOW DRAIN	Water
040500012608-05	Rivers/Streams in HUC 040500012608	Includes: Unnamed Tributary to Lake Michigan (Saint Joseph)	Water
040500020201-02	HUTCHINS LAKE	SW of Fennville.	Fish
040500020302-01	Rivers/Streams in HUC 040500020302	Includes: Unnamed Tributary to Bass Creek and Unnamed Tributary to Pigeon River	Fish and Water
040500020302-02	Rivers/Streams in HUC 040500020302	Includes: BLENDON AND OLIVE DRAIN (PIGEON RIVER HEADWATERS)	Water
040500020302-03	Rivers/Streams in HUC 040500020302	Includes: Pigeon River and Sawyer Creek	Water
040500020402-01	Rivers/Streams in HUC 040500020402	Includes: South Branch Macatawa River	Water
040500020408-01	LAKE MACATAWA	Vicinity of Holland (Park and Holland Twps.).	Fish
040500030507-04	GULL LAKE	Vicinity of Midland Park, Yorkville and Michigan State University's Kellogg Biological Station.	Fish
040500030508-01	Rivers/Streams in HUC 040500030508	Includes: Kalamazoo River tributaries from Gull Creek upstream to Wabascon Creek Confluence.	Water

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040500030508-04	Rivers/Streams in HUC 040500030508	Includes: WHITFORD LAKE OUTLET downstream to the Kalamazoo River.	Water
040500030508-05	Rivers/Streams in HUC 040500030508	Includes: Unnamed Tributary to Kalamazoo River in Ft. Custer.	Water
040500030508-07	Rivers/Streams in HUC 040500030508	Includes: Kalamazoo River (only-no tributaries) from Gull Creek upstream to Wabascon Creek Confluence.	Water
040500030508-08	Rivers/Streams in HUC 040500030508	Includes: Eagle Creek	Water
040500030509-01	Rivers/Streams in HUC 040500030509	Includes: Kalamazoo River tributaries from Morrow Pond Dam upstream to Gull Creek.	Water
040500030509-03	Rivers/Streams in HUC 040500030509	Includes: Kalamazoo River from Morrow Pond Dam upstream to Gull Creek (Morrow Pond is excluded).	Water
040500030602-04	EAGLE LAKE	W. of Kalamazoo.	Fish
040500030604-01	Rivers/Streams in HUC 040500030604	Includes: Kalamazoo River from Portage Creek confluence upstream to Morrow pond dam. Includes one unnamed tributary below Morrow dam.	Water
040500030604-02	Rivers/Streams in HUC 040500030604	Includes: Davis Creek from Kalamazoo River confluence to Cork Street	Water
040500030604-03	Rivers/Streams in HUC 040500030604	Includes: Davis Creek from Cork Street upstream	Water
040500030606-01	Rivers/Streams in HUC 040500030606	Includes: Kalamazoo River from tributary upstream of G Avenue upstream to Portage Creek confluence. Includes trib from Spring Valley.	Water
040500030606-03	Rivers/Streams in HUC 040500030606	Includes: Kalamazoo River	Water
040500030606-04	Rivers/Streams in HUC 040500030606	Includes: Arcadia Creek	Water
040500030607-01	Rivers/Streams in HUC 040500030607	Includes: Kalamazoo River and some, but not all, tributaries from old Plainwell Dam (downstream of Plainwell) upstream to Spring Brook confluence.	Water
040500030607-02	Rivers/Streams in HUC 040500030607	Includes: Kalamazoo River south split around Plainwell	Water

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040500030607-03	Rivers/Streams in HUC 040500030607	Includes: Unnamed Tributary to Kalamazoo River downstream of Kalamazoo at the Kalamazoo Nature Center	Water
040500030607-04	Rivers/Streams in HUC 040500030607	Includes: Silver Creek from Kalamazoo River confluence upstream to headwaters	Water
040500030607-05	Rivers/Streams in HUC 040500030607	Includes: Unnamed Tributary to Kalamazoo River (Chart Creek)	Water
040500030607-06	PINE LAKE	W. of Prairieville.	Fish
040500030701-08	GUN LAKE	Yankee Springs State Recreation Area.	Fish
040500030702-01	FENNER LAKE	NW of Martin (T2N, R11W, S15).	Fish
040500030702-08	FISH LAKE	East of Orangeville.	Fish
040500030803-01	SELKIRK LAKE	Vicinity of Shelbyville	Fish
040500030905-01	Rivers/Streams in HUC 040500030905	Includes: Osgood Drain from Kalamazoo River confluence upstream to Osgood Lake.	Water
040500030905-02	Rivers/Streams in HUC 040500030905	Includes: Kalamazoo River and tributaries, except Pine Creek, Gun River, and Schnable Brook, from Osgood Drain upstream to old dam (removed in 2008) downstream of Plainwell.	Water
040500030906-01	Rivers/Streams in HUC 040500030906	Includes: Kalamazoo River and tributaries from Rossman Creek upstream to Osgood Drain.	Water
040500030907-01	Rivers/Streams in HUC 040500030907	Includes: Kalamazoo River exclusively from Lake Allegan Dam upstream to Rossman Creek.	Water
040500030907-02	Rivers/Streams in HUC 040500030907	Includes: Dumont Creek and tributaries from Kalamazoo River confluence upstream to Dumont Lake.	Water
040500030907-03	Rivers/Streams in HUC 040500030907	Includes: Rossman Creek and tributaries from Kalamazoo River confluence upstream to headwaters.	Water
040500030909-01	Rivers/Streams in HUC 040500030909	Includes: Kalamazoo River from Rabbit River confluence upstream to Lake Allegan Dam.	Water
040500030909-02	Rivers/Streams in HUC 040500030909	Includes: Bear Creek and tributaries from Kalamazoo River confluence upstrean to headwaters.	Water
040500030909-03	Rivers/Streams in HUC 040500030909	Includes: Sand Creek and tributaries from Kalamazoo River confluence upstream to headwaters.	Water
040500030909-04	Rivers/Streams in HUC 040500030909	Includes: Unnamed Tributary to isolated Unnamed Lake	Water

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040500030911-01	Rivers/Streams in HUC 040500030911	Includes: Kalamazoo River from Mann Creek upstream to Rabbit River includes an UnNamed Tributary between these points.	Water
040500030911-02	Rivers/Streams in HUC 040500030911	Includes: Peach Orchard Creek and tributaries from Kalamazoo River confluence upstream to headwaters.	Water
040500030911-03	Rivers/Streams in HUC 040500030911	Includes: Kalamazoo River and tributaries from Peach Orchard Creek upstream to Mann Creek.	Water
040500040101-01	Rivers/Streams in HUC 040500040101	Includes: Unnamed Tributary to Willow Creek and Unnamed Tributaries to Little Wolf Lake and Wolf Lake	Fish
040500040102-01	Rivers/Streams in HUC 040500040102	Includes: Grass Lake Drain, Unnamed Tributaries to Grass Lake Drain, Unnamed Tributaries to Center Lake, Grass Lake, Leoni Millpond, and Tims Lake	Fish
040500040103-01	Rivers/Streams in HUC 040500040103	Includes: North Branch Grand River from confluence with Main Branch of Grand River to Center Lake outlet, and Unnamed Tributary to Little Olcott Lake	Fish
040500040103-05	Rivers/Streams in HUC 040500040103	Includes: Unnamed Tributary to Gilletts Lake	Fish
040500040104-01	Rivers/Streams in HUC 040500040104	Includes: Grand River	Fish
040500040105-01	Rivers/Streams in HUC 040500040105	Includes: Grand River and Sharp Creek	Fish and Water
040500040106-01	Rivers/Streams in HUC 040500040106	Includes: Grand River	Fish
040500040106-03	Rivers/Streams in HUC 040500040106	Includes: Grand River	Fish
040500040201-01	Rivers/Streams in HUC 040500040201	Includes: Cahaogan Creek	Fish
040500040202-01	Rivers/Streams in HUC 040500040202	Includes: Portage River	Fish
040500040203-01	Rivers/Streams in HUC 040500040203	Includes: Thornapple Creek	Fish
040500040204-01	Rivers/Streams in HUC 040500040204	Includes: Honey Creek and Portage River	Fish
040500040204-03	PORTAGE LAKE	NE of Jackson.	Fish

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040500040205-01	Rivers/Streams in HUC 040500040205	Includes: Batteese Creek	Fish
040500040206-01	Rivers/Streams in HUC 040500040206	Includes: Batteese Creek and Portage River	Fish
040500040207-01	Rivers/Streams in HUC 040500040207	Includes: Portage River and Wildcat Creek	Fish and Water
040500040208-01	Rivers/Streams in HUC 040500040208	Includes: Huntoon Creek	Fish
040500040209-01	Rivers/Streams in HUC 040500040209	Includes: Grand River, Pleasant Lake Drain, Shaw Branch, Western Creek and Whitney Drain	Fish
040500040210-01	Rivers/Streams in HUC 040500040210	Includes: Albrow Creek and Grand River	Fish
040500040210-02	Rivers/Streams in HUC 040500040210	Includes: Albrow Creek	Fish
040500040301-01	Rivers/Streams in HUC 040500040301	Includes: Sandstone Creek	Fish
040500040302-01	Rivers/Streams in HUC 040500040302	Includes: Mackey Brook and Sandstone Creek	Fish
040500040303-01	Rivers/Streams in HUC 040500040303	Includes: Sandstone Creek	Fish
040500040304-01	Rivers/Streams in HUC 040500040304	Includes: North Onondaga Drain	Fish
040500040305-01	Rivers/Streams in HUC 040500040305	Includes: Otter Creek and Spring Brook	Fish
040500040306-01	Rivers/Streams in HUC 040500040306	Includes: Spring Brook and Willow Creek	Fish
040500040307-01	Rivers/Streams in HUC 040500040307	Includes: Booth Drain and Spring Brook	Fish
040500040307-02	Rivers/Streams in HUC 040500040307	Includes: Spring Brook	Fish
040500040308-01	Rivers/Streams in HUC 040500040308	Includes: Grand River and Spring Brook	Fish
040500040308-02	Rivers/Streams in HUC 040500040308	Includes: Grand River	Fish
040500040401-01	Rivers/Streams in HUC 040500040401	Includes: Red Cedar River	Fish

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040500040401-02	Rivers/Streams in HUC 040500040401	Includes: Red Cedar River	Fish
040500040402-01	Rivers/Streams in HUC 040500040402	Includes: Middle Branch Red Cedar River	Fish and Water
040500040403-01	Rivers/Streams in HUC 040500040403	Includes: Red Cedar River	Fish
040500040403-02	Rivers/Streams in HUC 040500040403	Includes: Red Cedar River	Fish
040500040404-01	Rivers/Streams in HUC 040500040404	Includes: West Branch Red Cedar River	Fish
040500040405-01	Rivers/Streams in HUC 040500040405	Includes: West Branch Red Cedar River	Fish
040500040405-02	Rivers/Streams in HUC 040500040405	Includes: West Branch Red Cedar River	Fish
040500040406-01	Rivers/Streams in HUC 040500040406	Includes: Kalamink Creek	Fish
040500040407-01	Rivers/Streams in HUC 040500040407	Includes: Red Cedar River	Fish
040500040407-02	Rivers/Streams in HUC 040500040407	Includes: Wolf Creek	Fish
040500040407-03	WOLF CREEK	From Morrice Road upstream to headwaters.	Fish
040500040408-01	Rivers/Streams in HUC 040500040408	Includes: Doan Creek	Fish
040500040409-01	Rivers/Streams in HUC 040500040409	Includes: Dietz Creek	Fish
040500040410-01	Rivers/Streams in HUC 040500040410	Includes: Doan Creek and Doan Deer Creek	Fish
040500040411-01	Rivers/Streams in HUC 040500040411	Includes: Red Cedar River and Sullivan Creek	Fish
040500040411-02	Rivers/Streams in HUC 040500040411	Includes: Red Cedar River	Fish
040500040411-03	Rivers/Streams in HUC 040500040411	Includes: Squaw Creek	Fish
040500040501-01	Rivers/Streams in HUC 040500040501	Includes: Deer Creek	Fish
040500040502-01	Rivers/Streams in HUC 040500040502	Includes: Sloan Creek	Fish

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040500040502-02	Rivers/Streams in HUC 040500040502	Includes: Sloan Creek	Fish
040500040503-01	Rivers/Streams in HUC 040500040503	Includes: Unnamed Tributary to Red Cedar River	Fish
040500040503-02	Rivers/Streams in HUC 040500040503	Includes: Deer Creek	Fish
040500040503-03	Rivers/Streams in HUC 040500040503	Includes: Coon Creek and Red Cedar River	Fish
040500040504-01	Rivers/Streams in HUC 040500040504	Includes: Pine Lake Outlet	Fish
040500040505-01	Rivers/Streams in HUC 040500040505	Includes: Mud Creek	Fish
040500040506-01	Rivers/Streams in HUC 040500040506	Includes:Talmadge Drain and Sycamore Creek	Fish
040500040506-04	Rivers/Streams in HUC 040500040506	Includes: Cook and Thorburn Drain from Cedar Lake upstream	Fish
040500040507-01	Rivers/Streams in HUC 040500040507	Includes: Banta Drain and Sycamore Creek	Fish
040500040508-01	Rivers/Streams in HUC 040500040508	Includes: Herron Creek	Fish
040500040508-02	Rivers/Streams in HUC 040500040508	Includes: Red Cedar River	Fish
040500040508-03	Rivers/Streams in HUC 040500040508	Includes: Red Cedar River	Fish
040500040701-01	Rivers/Streams in HUC 040500040701	Includes: Columbia Creek	Fish
040500040702-01	Rivers/Streams in HUC 040500040702	Includes: Grand River	Fish
040500040702-02	Rivers/Streams in HUC 040500040702	Includes: Harris Drain, Skinner Extension Drain and Spicer Creek	Fish
040500040703-01	Rivers/Streams in HUC 040500040703	Includes: Grand River upstream of Waverly Rd	Fish
040500040703-02	MOORES PARK IMPOUNDMENT	Vicinity of Lansing from the Moores Park Dam u/s to Waverly Road.	Fish
040500040703-03	Rivers/Streams in HUC 040500040703	Includes: Grand River	Fish
040500040704-01	Rivers/Streams in HUC 040500040704	Includes: Unnamed Tributaries to the Grand River	Fish

AUID	Assessment Unit Name	Location Description	Source of Impairment
040500040704-02	Rivers/Streams in HUC 040500040704	Includes: Carrier Creek	Fish
040500040704-03	Rivers/Streams in HUC 040500040704	Includes: Grand River downstream of Waverly Rd, extending to confluence of Carrier Creek	Fish
040500040705-01	Rivers/Streams in HUC 040500040705	Includes: Miller Creek	Fish
040500040705-02	Rivers/Streams in HUC 040500040705	Includes: Grand River	Fish
040500040705-03	Rivers/Streams in HUC 040500040705	Includes: Sandstone Creek	Fish
040500040706-01	Rivers/Streams in HUC 040500040706	Includes: Grand River	Fish
040500040706-03	Rivers/Streams in HUC 040500040706	Includes: Frayer Creek and Grand River	Fish
040500040707-01	Rivers/Streams in HUC 040500040707	Includes: Sebewa Creek, Winchell and Union Drains	Fish
040500040708-01	Rivers/Streams in HUC 040500040708	Includes: Sebewa Creek	Fish
040500040709-01	Rivers/Streams in HUC 040500040709	Includes: Grand River	Fish
040500040710-01	Rivers/Streams in HUC 040500040710	Includes: Friend Brook and Grand River	Fish
040500040710-02	Rivers/Streams in HUC 040500040710	Includes: Goose Creek	Fish
040500050104-03	OVID LAKE	SW. of St. Johns off Price Road.	Fish
040500050301-02	NEVINS LAKE	3 miles SW of Stanton.	Fish
040500060104-03	MONTCALM LAKE	4 miles SW of Six Lakes.	Fish
040500060105-03	RAINBOW LAKE	E. of Trufant.	Fish
040500060107-04	LINCOLN LAKE	NW of Greenville.	Fish
040500060201-02	WABASIS LAKE, BIG	N. of Grattan.	Fish
040500060202-02	CLIFFORD LAKE	2 miles E. of Langston.	Fish
040500060204-02	LONG LAKE	NE of Belding and W. of Shiloh.	Fish
040500060301-01	Rivers/Streams in HUC 040500060301	Includes: Libhart Creek	Fish
040500060302-01	Rivers/Streams in HUC 040500060302	Includes: Libhart Creek	Fish
040500060302-02	Rivers/Streams in HUC 040500060302	Includes: Ayers Branch and Little Libhart Creek	Fish

AUID	Assessment Unit Name	Location Description	Source of Impairment
040500060302-03	Rivers/Streams in HUC 040500060302	Includes: Libhart Creek	Fish
040500060303-01	Rivers/Streams in HUC 040500060303	Includes: Bacon Creek and Prairie Creek	Fish
040500060304-01	Rivers/Streams in HUC 040500060304	Includes: Prairie Creek	Fish
040500060304-02	Rivers/Streams in HUC 040500060304	Includes: Prairie Creek	Fish
040500060305-01	Rivers/Streams in HUC 040500060305	Includes: Unnamed Tributary to Prairie Creek and Unnamed Tributary near Meade Road	Fish
040500060306-01	Rivers/Streams in HUC 040500060306	Includes: Prairie Creek	Fish
040500060307-01	Rivers/Streams in HUC 040500060307	Includes: Grand River	Water
040500060308-01	Rivers/Streams in HUC 040500060308	Includes: Sessions Creek	Fish
040500060308-03	Rivers/Streams in HUC 040500060308	Includes: Sessions Creek	Fish
040500060308-04	Rivers/Streams in HUC 040500060308	Includes: Sessions Creek	Fish
040500060309-01	Rivers/Streams in HUC 040500060309	Includes: Bellamy Creek, Grand River and Tibbetts Creek	Water
040500060310-01	Rivers/Streams in HUC 040500060310	Includes: Grand River	Water
040500060310-02	Rivers/Streams in HUC 040500060310	Includes: Crooked Creek	Water
040500060310-03	Rivers/Streams in HUC 040500060310	Includes: Red Creek	Water
040500060310-04	Rivers/Streams in HUC 040500060310	Includes: Timberland Creek	Water
040500060311-01	Rivers/Streams in HUC 040500060311	Includes: Leary Drain, Unnamed Tributary to Morrison Lake, and Unnamed Tributary near Clarksville Road	Fish
040500060311-02	Rivers/Streams in HUC 040500060311	Includes: Lake Creek and Little Creek	Fish
040500060312-01	Rivers/Streams in HUC 040500060312	Includes: Grand River	Water

AUID	Assessment Unit Name	Location Description	Source of Impairment
040500060312-02	Rivers/Streams in HUC 040500060312	Includes: Toles Creek	Water
040500060313-01	Rivers/Streams in HUC 040500060313	Includes: Grand River	Water
040500060313-02	Rivers/Streams in HUC 040500060313	Includes: Lee Creek	Water
040500060313-03	Rivers/Streams in HUC 040500060313	Includes: Unnamed Tributary to Grand River	Water
040500060313-04	Rivers/Streams in HUC 040500060313	Includes: Unnamed Tributary to Grand River	Water
040500060401-03	BILLS LAKE	S. of Croton.	Fish
040500060405-06	Long Lake	Kent County - Entire Lake	Fish
040500060501-01	Rivers/Streams in HUC 040500060501	Includes: Bear Creek and Waddell Creek	Fish
040500060501-02	Rivers/Streams in HUC 040500060501	Includes: Armstrong Creek, Bear Creek and Stout Creek	Fish
040500060502-01	Rivers/Streams in HUC 040500060502	Includes: Bear Creek and Grand River	Water
040500060502-02	Rivers/Streams in HUC 040500060502	Includes: Honey Creek	Water
040500060502-03	Rivers/Streams in HUC 040500060502	Includes: Egypt Creek	Water
040500060502-04	Rivers/Streams in HUC 040500060502	Includes: Unnamed Tributary to Grand River	Water
040500060502-05	Rivers/Streams in HUC 040500060502	Includes: Sunny Creek	Water
040500060503-01	Rivers/Streams in HUC 040500060503	Includes: Unnamed Tributary to Mill Creek	Fish
040500060503-02	Rivers/Streams in HUC 040500060503	Includes: Strawberry Creek	Fish
040500060503-03	Rivers/Streams in HUC 040500060503	Includes: Mill Creek	Fish
040500060503-04	Rivers/Streams in HUC 040500060503	Includes: Mill Creek	Fish
040500060504-01	Rivers/Streams in HUC 040500060504	Includes: Brandywine Creek and Indian Mill Creek	Fish
040500060504-02	Rivers/Streams in HUC 040500060504	Includes: Indian Mill Creek	Fish and Water

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040500060505-01	Rivers/Streams in HUC 040500060505	Includes: Unnamed Tributaries to Plaster Creek	Fish
040500060505-02	Rivers/Streams in HUC 040500060505	Includes: Plaster Creek	Fish
040500060506-01	Rivers/Streams in HUC 040500060506	Includes: Echo Lake Outlet and Unnamed Tributary to Unnamed Lake	Fish
040500060506-02	Rivers/Streams in HUC 040500060506	Includes: Little Plaster Creek, Plaster Creek and Whisky Creek	Fish
040500060507-01	Rivers/Streams in HUC 040500060507	Includes: Grand River	Water
040500060507-02	Rivers/Streams in HUC 040500060507	Includes: York Creek	Water
040500060507-03	Rivers/Streams in HUC 040500060507	Includes: Scott Creek	Water
040500060507-04	Rivers/Streams in HUC 040500060507	Includes: Lamberton Creek	Water
040500060507-05	Rivers/Streams in HUC 040500060507	Includes: LAMBERTON CREEK	Fish and Water
040500060507-06	Rivers/Streams in HUC 040500060507	Includes: Grand River	Water
040500060508-01	Rivers/Streams in HUC 040500060508	Includes: Buck Creek and Sharps Creek	Fish
040500060509-01	Rivers/Streams in HUC 040500060509	Includes: East Branch Rush Creek	Fish
040500060509-02	Rivers/Streams in HUC 040500060509	Includes: East Branch Rush Creek	Fish
040500060510-01	Rivers/Streams in HUC 040500060510	Includes: Unnamed Tributary to Buck Creek	Fish
040500060510-02	Rivers/Streams in HUC 040500060510	Includes: Buck Creek and Pine Hill Creek	Fish
040500060511-01	Rivers/Streams in HUC 040500060511	Includes: Rush Creek	Fish
040500060511-02	Rivers/Streams in HUC 040500060511	Includes: Rush Creek	Fish
040500060511-04	Rivers/Streams in HUC 040500060511	Includes: Unnamed Tributary to Rush Creek	Fish
040500060512-01	Rivers/Streams in HUC 040500060512	Includes: Grand River	Water

AUID	Assessment Unit Name	Location Description	Source of Impairment
040500060512-02	Rivers/Streams in HUC 040500060512	Includes: Unnamed Tributary to Grand River	Water
040500060512-03	Rivers/Streams in HUC 040500060512	Includes: Grand River	Water
040500060601-01	CROCKERY LAKE	3 miles NE of Conklin.	Fish
040500060601-03	Rivers/Streams in HUC 040500060601	Includes: North Branch Crockery Creek, west of Newaygo Rd.	Fish
040500060601-04	Rivers/Streams in HUC 040500060601	Includes: North Branch Crockery Creek	Fish
040500060601-05	Rivers/Streams in HUC 040500060601	Includes: North Branch Crockery Creek, east of Newaygo Rd	Fish
040500060602-01	Rivers/Streams in HUC 040500060602	Includes: Crockery Creek	Fish
040500060602-04	Rivers/Streams in HUC 040500060602	Includes: Unnamed Tributary to Crockery Creek	Fish
040500060602-05	Rivers/Streams in HUC 040500060602	Includes: Crockery Creek and Ovidhall Lake Creek	Fish
040500060602-06	Rivers/Streams in HUC 040500060602	Includes: Crockery Creek	Fish
040500060603-01	Rivers/Streams in HUC 040500060603	Includes: Crockery Creek	Fish
040500060603-02	Rivers/Streams in HUC 040500060603	Includes: Rio Grande Creek	Fish
040500060604-01	Rivers/Streams in HUC 040500060604	Includes: Crockery Creek	Fish
040500060604-02	Rivers/Streams in HUC 040500060604	Includes: Crockery Creek	Fish
040500060605-01	Rivers/Streams in HUC 040500060605	Includes: Brandy Creek and Crockery Creek	Fish and Water
040500060701-01	Rivers/Streams in HUC 040500060701	Includes: East Fork Sand Creek and Unnamed Tributaries to East Fork Sand Creek	Fish
040500060702-01	Rivers/Streams in HUC 040500060702	Includes: Sand Creek	Fish
040500060703-01	Rivers/Streams in HUC 040500060703	Includes: Sand Creek	Fish
040500060704-01	Rivers/Streams in HUC 040500060704	Includes: Beaver Creek, Deer Creek and Little Deer Creek	Fish

AUID	Assessment Unit Name	Location Description	Source of Impairment
040500060705-01	Rivers/Streams in HUC 040500060705	Includes: Grand River	Water
040500060705-03	Rivers/Streams in HUC 040500060705	Includes: Ottawa Creek	Water
040500060706-01	Rivers/Streams in HUC 040500060706	Includes: Bass Creek	Fish
040500060707-01	Rivers/Streams in HUC 040500060707	Includes: Bass Creek, Bass River and Little Bass Creek	Fish
040500060707-02	Rivers/Streams in HUC 040500060707	Includes: Bear Creek	Fish
040500060708-01	Rivers/Streams in HUC 040500060708	Includes: Grand River, not including tributaries	Water
040500060708-02	Rivers/Streams in HUC 040500060708	Includes: Tributaries to Grand River	Water
040500060709-01	Rivers/Streams in HUC 040500060709	Includes: Unnamed Tributaries to Pottawattomie Bayou	Fish
040500060710-01	Rivers/Streams in HUC 040500060710	Includes: Norris Creek	Fish
040500060711-02	Rivers/Streams in HUC 040500060711	Includes: Beckwith Brook, Stevens Creek, Vincent Creek and Willow Hill Creek	Fish
040500060711-03	Rivers/Streams in HUC 040500060711	Includes: Norris Creek	Fish
040500060712-02	Rivers/Streams in HUC 040500060712	Includes: Black Creek, Grand River and Lloyd Bayou	Water
040500070105-01	Rivers/Streams in HUC 040500070105	Includes: Thornapple River	Fish
040500070201-01	Rivers/Streams in HUC 040500070201	Includes: Thornapple River	Fish
040500070201-03	Rivers/Streams in HUC 040500070201	Includes: Darken and Boyer Drain, Cole Wright Helms Drain, and Unnamed Tributaries to Darken and Boyer Drain	Fish
040500070202-01	Rivers/Streams in HUC 040500070202	Includes: Lacey Creek and Unnamed Tributary near Carlisle Highway	Fish
040500070209-01	Rivers/Streams in HUC 040500070209	Includes: High Bank Creek	Fish
040500070209-02	Rivers/Streams in HUC 040500070209	Includes: Mud Creek	Fish
040500070209-04	FINE LAKE	E. of Hickory Corners.	Fish

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040500070209-05	BRISTOL LAKE	1 mile SE of Bristol Corners.	Fish
040500070211-01	THORNAPPLE LAKE	SE of Hastings.	Fish
040500070301-01	Rivers/Streams in HUC 040500070301	Includes: Tupper Creek	Fish
040500070301-02	JORDAN LAKE	In the vicinity of Lake Odessa.	Fish
040500070303-01	Rivers/Streams in HUC 040500070303	Includes: Coldwater River, Kart Creek and Messer Brook	Fish
040500070305-01	Rivers/Streams in HUC 040500070305	Includes: Kilgus Branch	Fish
040500070307-03	Rivers/Streams in HUC 040500070307	Includes: Coldwater River	Fish
040500070402-03	Rivers/Streams in HUC 040500070402	Includes: Butler Creek	Fish
040500070402-04	Rivers/Streams in HUC 040500070402	Includes: Pratt Creek and Unnamed Tributary to Pratt Creek	Fish
040500070404-01	Rivers/Streams in HUC 040500070404	Includes: Thornapple River	Fish
040500070405-01	Rivers/Streams in HUC 040500070405	Includes: Duncan Lake Outlet and Wilson Drain	Fish
040500070405-03	Rivers/Streams in HUC 040500070405	Includes: Hanna Lake Outlet and Unnamed Tributary to Hanna Lake	Fish
040500070406-01	Rivers/Streams in HUC 040500070406	Includes: Hill Creek and Thornapple River	Fish
040500070407-02	Rivers/Streams in HUC 040500070407	Includes: Krafts Lake Outlet	Fish
040500070407-03	Rivers/Streams in HUC 040500070407	Includes: McCords Creek	Fish
040500070407-04	Rivers/Streams in HUC 040500070407	Includes: UNNAMED TRIBUTARY TO THORNAPPLE RIVER	Fish
040601010104-02	HAMLIN LAKE	Vicinity of Hamlin Lakes.	Fish
040601010503-02	Rivers/Streams in HUC 040601010503	Includes: Baldwin River and Bray Creek	Water
040601010503-03	Rivers/Streams in HUC 040601010503	Includes: Sanborn Creek	Water
040601010504-05	Rivers/Streams in HUC 040601010504	Includes: Pere Marquette River	Water
040601010506-01	Rivers/Streams in HUC 040601010506	Includes: Pere Marquette River, not including tributaries	Water

AUID	Assessment Unit Name	Location Description	Source of Impairment
040601010506-02	Rivers/Streams in HUC 040601010506	Includes: Pere Marquette River	Water
040601010507-03	Rivers/Streams in HUC 040601010507	Includes: Pere Marquette River	Water
040601010508-01	Rivers/Streams in HUC 040601010508	Includes: Pere Marquette River	Water
040601010508-02	Rivers/Streams in HUC 040601010508	Includes: Swan Creek	Water
040601010508-03	Rivers/Streams in HUC 040601010508	Includes: India Creek	Water
040601010508-04	Rivers/Streams in HUC 040601010508	Includes: Pere Marquette River	Water
040601010702-01	Rivers/Streams in HUC 040601010702	Includes: Fivemile Creek	Water
040601010704-01	Rivers/Streams in HUC 040601010704	Includes: Rattlesnake Creek and South Branch White River	Water
040601010704-02	Rivers/Streams in HUC 040601010704	Includes: BLACK (DELONG) CREEK	Water
040601010704-03	Rivers/Streams in HUC 040601010704	Includes: BLACK (DELONG) CREEK	Water
040601010704-04	ROBINSON LAKE	Vicinity of Jugville 4 miles SW of White Cloud.	Fish
040601010704-05	Rivers/Streams in HUC 040601010704	Includes: Robinson Creek	Water
040601010901-03	BIG BLUE LAKE	N. of Lakewood.	Fish
040601010904-01	WHITE LAKE	Vicinity of Montague and Whitehall.	Fish
040601011007-01	Rivers/Streams in HUC 040601011007	Includes: FLOWER CREEK (EXCLUDING N. BR.)	Water
040601011007-02	Rivers/Streams in HUC 040601011007	Includes: FLOWER CREEK	Water
040601011007-03	Rivers/Streams in HUC 040601011007	Includes: North Branch Flower Creek	Water
040601020101-02	HIGGINS LAKE	Vicinity of Roscommon.	Fish
040601020302-05	LAKE MITCHELL	W. of Cadillac.	Fish
040601020501-03	LILY LAKE	NE of Lake George.	Fish
040601020603-03	TODD LAKE	W. of Slaybaugh Corner.	Fish
040601020701-01	Rivers/Streams in HUC 040601020701	Includes: Brown Creek and Unnamed Tributaries near One Mile Road (Osceola County) and 130th Ave (Mecosta County)	Water

AUID	Assessment Unit Name	Location Description	Source of Impairment
040601020701-02	Rivers/Streams in HUC 040601020701	Includes: Blodgett Creek, Buckhorn Creek and Muskegon River	Water
040601020806-02	LITTLE WHITEFISH LAKE	3 miles NW of Pierson.	Fish
040601020809-01	Rivers/Streams in HUC 040601020809	Includes: Rice Creek and Tamarack Creek	Water
040601020901-02	CROTON DAM POND	Vicinity of Croton and Croton Heights.	Fish
040601020902-02	Rivers/Streams in HUC 040601020902	Includes: Bigelow Creek and Cold Creek	Fish
040601020903-01	Rivers/Streams in HUC 040601020903	Includes: Muskegon River excluding 1 mile stretch below Croton Dam	Fish
040601020903-04	SYLVAN LAKE AND EMERALD LAKES	Reaches contained in HUC 040601020903	Fish
040601020903-05	Rivers/Streams in HUC 040601020903	Includes: Muskegon River from Croton dam downstream 1 mile	Fish
040601020904-01	Rivers/Streams in HUC 040601020904	Includes: Fourmile Creek and Muskegon River	Fish
040601020904-02	Rivers/Streams in HUC 040601020904	Includes: Brooks Creek	Fish
040601020905-03	FREMONT LAKE	SHERIDAN TWP., near city of Freemont (T12N, R14W, S2,3,4,9,10,11)	Fish
040601020905-04	Rivers/Streams in HUC 040601020905	Includes: Brooks Creek and Cow Creek	Fish
040601020905-11	Rivers/Streams in HUC 040601020905	Includes: Butler Creek and Williams Creek	Water
040601020906-01	Rivers/Streams in HUC 040601020906	Includes: Greenwood Creek and Muskegon River	Fish
040601020906-02	Rivers/Streams in HUC 040601020906	Includes: Sand Creek	Fish
040601020906-03	Rivers/Streams in HUC 040601020906	Includes: Minnie Creek	Fish
040601020906-04	Rivers/Streams in HUC 040601020906	Includes: Minnie Creek	Fish
040601021002-04	Rivers/Streams in HUC 040601021002	Includes: Maple River, Middle Channel Muskegon River, Mosquito Creek, Muskegon River and Spring Creek	Fish
040601021004-03	Rivers/Streams in HUC 040601021004	Includes: Middle Channel Muskegon River	Fish

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040601030104-04	LAKE MARGRETHE	SW of Grayling.	Fish
040601030301-01	Rivers/Streams in HUC 040601030301	Includes: Anderson Creek and West Branch Anderson Creek	Water
040601030307-01	Rivers/Streams in HUC 040601030307	Includes: Perkins Creek and Slagle Creek	Water
040601030505-01	Rivers/Streams in HUC 040601030505	Includes: Bear Creek, Boswell Creek, Cedar Creek, Chicken Creek and Podunk Creek	Water
040601040103-04	NORTH LAKE LEELANAU	Vicinity of Leland.	Fish
040601040202-01	LAKE ANN	Vicinity of Lake Ann.	Fish
040601040302-03	GREEN LAKE	Vicinity of Interlochen.	Fish
040601040402-01	GLEN LAKE	South of Glen Arbor.	Fish
040601040405-02	PORTAGE LAKE	Vicinity of Onekama.	Fish
040601050102-02	WALLOON LAKE	Vicinity of Walloon Lake.	Fish
040601050204-02	DEER LAKE	3 miles SE of Boyne City.	Fish
040601050301-03	SIX MILE LAKE	4 miles SW of East Jordan.	Fish
040601050302-06	ELLSWORTH LAKE	Vicinity of Ellsworth.	Fish
040601050304-08	LAKE BELLAIRE	Vicinity of Bellaire.	Fish
040601050305-01	TORCH LAKE	Vicinity of Eastport.	Fish
040601050404-02	ELK LAKE	Vicinity of Elk Rapids.	Fish
040601050501-01	Rivers/Streams in HUC 040601050501	Includes: Crofton Creek, Failing Creek, Hauenstein Creek, North Branch Boardman River and Palmer Creek	Fish
040601050502-01	Rivers/Streams in HUC 040601050502	Includes: South Branch Boardman River and Taylor Creek	Fish
040601050503-01	Rivers/Streams in HUC 040601050503	Includes: North Branch Boardman River	Fish
040601050504-01	Rivers/Streams in HUC 040601050504	Includes: Boardman River, Carpenter Creek and Twentytwo Creek	Fish
040601050504-02	BROWN BRIDGE POND	Impoundment of the Boardman River NE of Mayfield.	Fish
040601050506-02	ARBUTUS LAKE	SE of Traverse City.	Fish
040601050507-05	BASS LAKE	SW of Traverse City.	Fish
040601050507-07	SILVER LAKE	6 miles SW of Traverse City.	Fish
040601060103-03	MANISTIQUE LAKE	13 miles SW of Dollarville.	Fish
040601060201-02	WEST BRANCH LAKES	T48N, R14W, Sec. 31.	Fish
040601060207-01	Rivers/Streams in HUC 040601060207	Includes: Dead Creek	Water

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040601060402-02	BOOT LAKE	13 miles NW of Hiawatha.	Fish
040601060411-01	Rivers/Streams in HUC 040601060411	Includes: Bear Slough, Brace Creek, Hay Meadow Creek, Hiawatha Creek and Stutts Creek	Water
040601060603-03	Dodge Lake	1 Mile South of Hiawatha	Fish
040601060604-01	Rivers/Streams in HUC 040601060604	Includes: Manistique River	Water
040601060604-02	Rivers/Streams in HUC 040601060604	Includes: Manistique River	Fish and Water
040601070203-01	Rivers/Streams in HUC 040601070203	Includes: Doe Creek	Water
040601070203-02	Rivers/Streams in HUC 040601070203	Includes: Furlong Creek	Water
040601070203-03	Rivers/Streams in HUC 040601070203	Includes: East Branch Furlong Creek, West Branch Furlong Creek, and Furlong Creek	Water
040601070204-05	MILLECOQUINS LAKE	NW of Naubinway.	Fish
040601070209-01	MILAKOKIA LAKE	W. of Gould City.	Fish
040601070211-05	GULLIVER LAKE	Vicinity of Gulliver, S of R#2.	Fish
040700010201-01	Rivers/Streams in HUC 040700010201	Includes: Munuscong River	Water
040700010204-01	Rivers/Streams in HUC 040700010204	Includes: Munuscong River	Water
040700020101-01	Rivers/Streams in HUC 040700020101	Includes: Carp River and Ozark Creek	Water
040700020101-02	CARP LAKE (AKA: TROUT LAKE)	Vicinity of the community of Trout Lake (SW corner of Chippewa Co.).	Fish
040700020207-01	Rivers/Streams in HUC 040700020207	Includes: Bear Creek and Little Bear Creek	Water
040700020207-02	Rivers/Streams in HUC 040700020207	Includes: Bear Creek	Water
040700020211-01	Rivers/Streams in HUC 040700020211	Includes: Crooked Creek, Garden Hill Creek, Home Creek, Pine River and Rock Spring Creek	Water
040700020211-02	Rivers/Streams in HUC 040700020211	Includes: Pine River	Water
040700020301-03	CARIBOU LAKE	West of DeTour Village.	Fish
040700030201-02	EMMA LAKE	15 miles SW of Rogers City, E. of Rt. F21.	Fish
040700030202-02	NETTIE LAKE	SE of Millersburg.	Fish

AUID	Assessment Unit Name	Location Description	Source of Impairment
040700030202-03	LOST LAKE	West of Hawks, east of Nettie Lake.	Fish
040700040202-02	PICKEREL LAKE	SE of Alanson.	Fish
040700040208-05	CROOKED LAKE	Vicinity of Oden and Ponshewaing.	Fish
040700040209-06	BURT LAKE	Vicinity of Indian River.	Fish
040700040403-06	MULLETT LAKE	S. of Cheboygan and E. of Burt Lake.	Fish
040700050302-02	Rivers/Streams in HUC 040700050302	Includes: Black River, Fisher Creek and Stewart Creek	Water
040700060101-02	BEAVER LAKE	SE of Fletcher Pond and SW of Alpena.	Fish
040700060204-02	FLETCHER POND	16 miles SW of Alpena.	Fish
040700060301-02	GAYLANTA LAKE	1 mile W. of Bigelow.	Fish
040700060401-02	ESS LAKE	13 miles NE of Atlanta in Mackinaw State Forest.	Fish
040700060401-03	LONG LAKE	5.5 miles NW of Hillman.	Fish
040700060503-01	Rivers/Streams in HUC 040700060503	Includes: Fish Creek, Pettis Creek, Sucker Creek and Vincent Creek	Water
040700060504-02	HUBBARD LAKE	Vicinity of Backus Beach.	Fish
040700060603-01	Rivers/Streams in HUC 040700060603	Includes: Gaffney Creek and Thunder Bay River	Water
040700060604-01	LAKE WINYAH (AKA: SEVEN MILE POND) OF THUNDER BAY RIVER	7 Miles NW of Alpena.	Fish
040700060605-01	LAKE BESSER	Vicinity of Alpena u/s from Ninth Street Dam.	Fish
040700060605-03	FOURMILE POND	Thunder Bay area.	Fish
040700070704-01	ALCONA DAM POND	Vicinity of the Alcona County Park NW of Bamfield and Glennie off Hwy-F32.	Fish
040700070709-01	Rivers/Streams in HUC 040700070709	Includes: Au Sable River below Foote dam and Old Au Sable River	Fish
040801010203-01	Rivers/Streams in HUC 040801010203	Includes: Guiley Creek	Water
040801010203-02	Rivers/Streams in HUC 040801010203	Includes: Picket Creek	Water
040801010204-01	Rivers/Streams in HUC 040801010204	Includes: Manary Creek, Saddler Creek and Sand Creek	Water
040801010204-02	FLOYD LAKE	8.5 miles NW of Tawas City.	Fish
040801010307-01	Rivers/Streams in HUC 040801010307	Includes: Au Gres River and Burnt Drain	Water
040801010307-02	Rivers/Streams in HUC 040801010307	Includes: Old Channel East Branch Au Gres and Tributaries	Water

AUID	Assessment Unit Name	Location Description	Source of Impairment
040801010410-04	HARDWOOD LAKE	NW corner of Richland Twp.	Fish
040801010411-01	Rivers/Streams in HUC 040801010411	Includes: Saverine Creek and Unnamed Tributaries to Saverine Creek	Fish
040801010412-01	Rivers/Streams in HUC 040801010412	Includes: Rifle River and Unnamed Tributaries to Rifle River	Fish
040801010412-03	Rivers/Streams in HUC 040801010412	Includes: Rifle River	Fish and Water
040801010501-01	Rivers/Streams in HUC 040801010501	Includes: Chub Creek and Plains Creek	Water
040801010502-01	Rivers/Streams in HUC 040801010502	Includes: Old Channel (Rifle River) and Unnamed Tributaries to Old Channel (Rifle River)	Fish
040801020201-01	Rivers/Streams in HUC 040801020201	Includes: Kawkawlin Creek and North Branch Kawkawlin River	Water
040801020205-01	Rivers/Streams in HUC 040801020205	Includes: Crump Drain, Kawalski Drain, Monison Drain, North Branch Kawkawlin River and Renner Drain	Water
040801020205-02	Rivers/Streams in HUC 040801020205	Includes: Bedell Drain and North Branch Kawkawlin River	Water
040801020205-03	Rivers/Streams in HUC 040801020205	Includes: Hembling Drain, McNally Drain, and Unnamed Tributaries to Hembling Drain	Water
040801040101-01	Rivers/Streams in HUC 040801040101	Includes: East Branch Willow Creek	Water
040802010201-07	CRANBERRY LAKE	NE of Harrison.	Fish
040802010203-02	PRATT LAKE	4 miles NW of Gladwin.	Fish
040802010303-03	FIVE LAKES	NW of Clare.	Fish
040802010402-01	Rivers/Streams in HUC 040802010402	Includes: South Branch Little Sugar River	Water
040802010407-02	WIXOM LAKE	Impoundment of Tittabawassee River u/s of Edenville and Rt. 30 and about 16 miles NW of Midland.	Fish
040802010408-01	Rivers/Streams in HUC 040802010408	Includes: Tittabawassee River and Varity Creek	Fish
040802010408-02	Rivers/Streams in HUC 040802010408	Includes: Black Creek	Fish
040802010408-03	SANFORD LAKE	NW of Midland at Sanford.	Fish
040802010507-01	Rivers/Streams in HUC 040802010507	Includes: Salt River	Water

AUID	Assessment Unit Name	Location Description	Source of Impairment
040802010601-01	Rivers/Streams in HUC 040802010601	Includes: Carrol Creek Drain	Fish
040802010602-01	Rivers/Streams in HUC 040802010602	Includes: Grass Creek and Sturgeon Creek	Fish
040802010603-01	Rivers/Streams in HUC 040802010603	Includes: Unnamed Tributary to Newell Drain	Fish
040802010603-02	Rivers/Streams in HUC 040802010603	Includes: Branch Number Two, Jacobs Drain, Miller Drain, Newell Drain and Sturgeon Creek	Fish
040802010604-02	Rivers/Streams in HUC 040802010604	Includes: Averill Creek, Prairie Creek, and Tittabawassee River	Fish
040802010604-03	Rivers/Streams in HUC 040802010604	Includes: Tittabawassee River downstream from 460 feet downstream of Poseyville Road	Fish
040802010605-01	Rivers/Streams in HUC 040802010605	Includes: Bullock Creek, Duncan Drain, Kneeland Drain, and Unnamed Tributaries to Bullock Creek	Fish
040802010606-01	Rivers/Streams in HUC 040802010606	Includes: Tittabawassee River	Fish
040802010606-02	Rivers/Streams in HUC 040802010606	Includes: Tittabawassee River	Fish
040802010606-03	Rivers/Streams in HUC 040802010606	Includes: Lingle Drain, Sarle Drain, Shaffner Drain, Brown and Mills Drain	Fish
040802010607-01	Rivers/Streams in HUC 040802010607	Includes: Tittabawassee River	Fish and Water
040802010607-02	Rivers/Streams in HUC 040802010607	Includes: Tributaries to the Tittabawassee River	Fish and Water
040802020204-03	LITTLEFIELD LAKE	N. of Weidman.	Fish
040802020204-07	COLDWATER LAKE	NW Mt. Pleasant and S. of Weidman.	Fish
040802020205-04	STEVENSON LAKE	5 miles SW of Clare W. of US-27.	Fish
040802020207-01	Rivers/Streams in HUC 040802020207	Includes: Chippewa River, Johnson Creek and Stony Brook	Water
040802020207-02	Rivers/Streams in HUC 040802020207	Includes: Chippewa River	Fish
040802020207-03	Rivers/Streams in HUC 040802020207	Includes: Chippewa River	Fish
040802020207-04	Rivers/Streams in HUC 040802020207	Includes: Chippewa River	Fish
040802020207-05	Rivers/Streams in HUC 040802020207	Includes: Cedar Creek	Fish

AUID	Assessment Unit Name	Location Description	Source of Impairment
040802020304-02	Rivers/Streams in HUC 040802020304	Includes: UNNAMED TRIBUTARY TO WOLF CREEK	Water
040802020304-04	ROCK LAKE	NW of Vestaburg. E. of Pine Grove; E. of Pine Grove Road and N. or M-46.	Fish
040802020312-03	ALMA IMPOUNDMENT	Impoundment of the Pine River in the vicinity of Alma.	Fish
040802020403-01	Rivers/Streams in HUC 040802020403	Includes: Pine River	Water
040802020403-02	Rivers/Streams in HUC 040802020403	Includes: Sugar Creek	Water
040802020403-03	Rivers/Streams in HUC 040802020403	Includes: Pine River	Water
040802020403-04	ST. LOUIS IMPOUNDMENT	St. Louis Impoundment of Pine River in the vicinity of St. Louis.	Fish and Water
040802020403-05	Rivers/Streams in HUC 040802020403	Includes: Horse Creek	Water
040802020501-01	Rivers/Streams in HUC 040802020501	Includes: Chippewa River and Mission Creek	Fish
040802020502-01	Rivers/Streams in HUC 040802020502	Includes: Parcher Drain and Salt Creek	Fish
040802020503-01	Rivers/Streams in HUC 040802020503	Includes: Childs Creek and Salt Creek	Fish
040802020504-01	Rivers/Streams in HUC 040802020504	Includes: Onion Creek and Potter Creek	Fish
040802020504-02	Rivers/Streams in HUC 040802020504	Includes: Potter Creek	Fish
040802020505-01	Rivers/Streams in HUC 040802020505	Includes: Black Creek, Salt Creek and Thrasher Creek	Fish
040802020506-01	Rivers/Streams in HUC 040802020506	Includes: Little Salt Creek	Fish
040802020506-02	Rivers/Streams in HUC 040802020506	Includes: Little Salt Creek	Fish
040802020507-01	Rivers/Streams in HUC 040802020507	Includes: Little Salt Creek and Turkey Creek	Fish
040802020508-01	Rivers/Streams in HUC 040802020508	Includes: Chippewa River	Fish
040802020508-02	Rivers/Streams in HUC 040802020508	Includes: Chippewa River	Fish

AUID	Assessment Unit Name	Location Description	Source of Impairment
040802020508-03	Rivers/Streams in HUC 040802020508	Includes: Chippewa River	Fish
040802020508-04	Rivers/Streams in HUC 040802020508	Includes: Chippewa River	Fish
040802030104-01	Rivers/Streams in HUC 040802030104	Includes: Bogue Creek	Fish
040802030104-02	THOMPSON LAKE	Vicinity of Howell.	Fish
040802030108-08	LAKE PONEMAH	NW of Fenton.	Fish
040802030108-09	FENTON LAKE	Vicinity of Fenton.	Fish
040802030109-05	LOBDELL LAKE	2 miles SW of Linden (Argentine Twp.).	Fish
040802030209-01	Rivers/Streams in HUC 040802030209	Includes: Shiawassee River	Water
040802030309-01	Rivers/Streams in HUC 040802030309	Includes: Bad River and Shad Creek	Water
040802030310-01	Rivers/Streams in HUC 040802030310	Includes: South Fork Bad River	Water
040802030410-02	Rivers/Streams in HUC 040802030410	Includes: Ferguson Bayou	Water
040802030410-03	Rivers/Streams in HUC 040802030410	Includes: Shiawassee River	Water
040802030410-04	Rivers/Streams in HUC 040802030410	Includes: Unnamed Tributaries to Shiawassee River	Water
040802030410-05	Rivers/Streams in HUC 040802030410	Includes: Marsh Creek	Water
040802030410-06	Rivers/Streams in HUC 040802030410	Includes: Shiawassee River	Water
040802040104-03	LAKE NEPESSING	SW of Lapeer, Elba Twp.	Fish
040802040106-01	Rivers/Streams in HUC 040802040106	Includes: Sand Hill Drain and South Branch Flint River	Water
040802040302-02	BIG SEVEN LAKE (SEVEN LAKES)	2.5 miles NW of Holly.	Fish
040802040303-05	WILDWOOD LAKE	5 miles E. of Holly.	Fish
040802040306-01	Rivers/Streams in HUC 040802040306	Includes: Thread Creek	Water
040802040306-02	Rivers/Streams in HUC 040802040306	Includes: Bush Creek, Pierson Branch and Thread Creek	Water
040802040408-01	Rivers/Streams in HUC 040802040408	Includes: Chipmunk Creek and Kearsley Creek	Water

AUID	Assessment Unit Name	Location Description	Source of Impairment
040802040408-02	Rivers/Streams in HUC 040802040408	Includes: Kearsley Creek	Water
040802040513-01	Rivers/Streams in HUC 040802040513	Includes: Atwell Drain, Flint River, Pitch Creek and Spring Brook Drain	Water
040802040513-02	Rivers/Streams in HUC 040802040513	Includes: Flint River	Water
040802050101-01	Rivers/Streams in HUC 040802050101	Includes: South Branch Cass River	Fish
040802050102-01	Rivers/Streams in HUC 040802050102	Includes: Carter Drain and Unnamed Tributaries to Carter Drain	Fish
040802050102-02	Rivers/Streams in HUC 040802050102	Includes: Duff Creek and South Branch Cass River	Fish
040802050103-01	Rivers/Streams in HUC 040802050103	Includes: South Branch Cass River	Fish
040802050104-01	Rivers/Streams in HUC 040802050104	Includes: Argyle Drain, Carson Drain, Hartel Drain, Middle Branch Cass River and Sanderson Drain	Fish
040802050105-01	Rivers/Streams in HUC 040802050105	Includes: Hawksworth Drain, Kramp Drain, McIntyre Drain, Middle Branch Cass River, Swan Drain and Wheeler Drain	Fish
040802050106-01	Rivers/Streams in HUC 040802050106	Includes: South Branch Cass River and Stony Creek	Fish
040802050106-02	Rivers/Streams in HUC 040802050106	Includes: Ryder Drain and Turtle Creek	Fish
040802050106-03	Rivers/Streams in HUC 040802050106	Includes: Beaver Creek, Kirby Drain, Middle Branch Cass River, South Branch Cass River, Tank Drain and Temple Drain	Fish
040802050107-01	Rivers/Streams in HUC 040802050107	Includes: Brown Drain, Osentoski Branch, Schiestel Drain and South Fork Cass River	Fish
040802050108-01	Rivers/Streams in HUC 040802050108	Includes: North Branch Cass River	Fish
040802050109-01	Rivers/Streams in HUC 040802050109	Includes: North Branch Cass River and Sanilac Huron Creek	Fish
040802050110-01	Rivers/Streams in HUC 040802050110	Includes: Greenman Creek and South Branch Cass River	Fish
040802050205-01	Rivers/Streams in HUC 040802050205	Includes: Cass River	Fish

AUID	Assessment Unit Name	Location Description	Source of Impairment
040802050207-01	Rivers/Streams in HUC 040802050207	Includes: Cass River	Fish
040802050207-02	Rivers/Streams in HUC 040802050207	Includes: Butternut Creek, Cass River, and Tributaries to the Cass River	Fish
040802050208-01	Rivers/Streams in HUC 040802050208	Includes: Cass River	Fish
040802050208-02	CARO IMPOUNDMENT	Vicinity of Caro u/s.	Fish
040802050301-02	MURPHY LAKE	NE of Millington and SW of Mayville.	Fish
040802050303-01	Rivers/Streams in HUC 040802050303	Includes: Millington Creek	Water
040802050303-02	Rivers/Streams in HUC 040802050303	Includes: Cass River	Water
040802050304-01	Rivers/Streams in HUC 040802050304	Includes: Carpenter Branch, Dead Creek and Zehender Drain	Fish
040802050304-02	Rivers/Streams in HUC 040802050304	Includes: Dead Creek	Fish
040802050305-01	Rivers/Streams in HUC 040802050305	Includes: Cass River, not including tributaries.	Fish
040802050305-03	Rivers/Streams in HUC 040802050305	Includes: Cass River	Fish
040802050305-04	Rivers/Streams in HUC 040802050305	Includes: Unnamed trib to the Cass River, east of Frankenmuth	Fish
040802050305-05	Rivers/Streams in HUC 040802050305	Includes: Coles Creek and Unnamed Tributaries to the Cass River	Fish
040802050306-01	Rivers/Streams in HUC 040802050306	Includes: Cass River	Fish and Water
040802050306-03	Rivers/Streams in HUC 040802050306	Includes: Cass River	Fish and Water
040802060201-01	Rivers/Streams in HUC 040802060201	Includes: Saginaw River and Unnamed Tributaries to Saginaw River	Water
040802060204-01	Rivers/Streams in HUC 040802060204	Includes: Saginaw River	Water
040802060204-03	Rivers/Streams in HUC 040802060204	Includes: Saginaw River and Unnamed Tributaries to Saginaw River	Water

AUID	Assessment Unit Name	Location Description	Source of Impairment
040900010214-01	Rivers/Streams in HUC 040900010214	Includes: Black River, Brandymore Drain, Howe Drain, Price Drain, Stocks Creek, Unnamed Tributaries to Black River, Unnamed Tributaries to Brandymore Drain, Unnamed Tributaries to Howe Drain, and Unnamed Tributariest to Stocks Creek	Water
040900010214-02	Rivers/Streams in HUC 040900010214	Includes: Black River	Water
040900010407-01	Rivers/Streams in HUC 040900010407	Includes: Belle River Including Tributaries	Water
040900010407-02	Rivers/Streams in HUC 040900010407	Includes: WEBSTER DRAIN	Water
040900030103-08	MACEDAY LAKE	Vicinity of Waterford.	Fish
040900030106-02	LAKEVILLE LAKE	Vicinity of Lakeville NW of Romeo.	Fish
040900030108-03	CASS LAKE	Vicinity of Keego Harbor and West Bloomfield.	Fish
040900030109-02	STONY CREEK IMPOUNDMENT	Stony Creek Metropolitan Park, vicinity of Romeo.	Fish
040900030306-01	Rivers/Streams in HUC 040900030306	Includes: Armada and Ray Drain, Coon Creek, Priest Drain, Tupper Brook, Unnamed Tributaries to Coon Creek, and Unnamed Tributary to Priest Drain	Water
040900030309-01	Rivers/Streams in HUC 040900030309	Includes: Bannister Drain, Crittenden Drain, Decker Drain, Dunn Drain, Harris Drain, Kenner Drain, Lewis Drain, Longstaff Drain, Longstaff Drain Number Two, Shoemaker Drain, Unnamed Tributary to Middle Branch Clinton River, and Utica Drain	Water
040900030310-02	Rivers/Streams in HUC 040900030310	Includes: North Branch Clinton River and Wyman Drain	Fish
040900030402-01	Rivers/Streams in HUC 040900030402	Includes: Clinton River and Unnamed Tributaries to Clinton River	Water
040900030402-02	Rivers/Streams in HUC 040900030402	Includes: Clinton River from Gratiot Avenue downstream to the mouth	Water
040900030402-03	Rivers/Streams in HUC 040900030402	Includes: Clinton River	Water
040900030402-04	Rivers/Streams in HUC 040900030402	Includes: Clinton River, Cranberry Marsh Drain, Faulman Drain, Hildebrandt Drain, Kukuk Drain, and Unnamed Tributaries to Clinton River	Water

AUID	Assessment Unit Name	Location Description	Source of Impairment
040900040103-01	Rivers/Streams in HUC 040900040103	Includes: Smith Drain and Upper River Rouge	Water
040900040103-02	Rivers/Streams in HUC 040900040103	Includes: Seeley Drain	Water
040900040103-03	Rivers/Streams in HUC 040900040103	Includes: Minnow Pond Drain	Water
040900040201-01	Rivers/Streams in HUC 040900040201	Includes: Johnson Drain	Water
040900040201-02	Rivers/Streams in HUC 040900040201	Includes: Sump Drain	Water
040900040201-03	Rivers/Streams in HUC 040900040201	Includes: Johnson Drain	Water
040900040203-05	WALLED LAKE	Vicinity of Novi.	Fish
040900040203-09	NEWBURGH LAKE	Middle River Rouge impoundment in the vicinity of Plymouth.	Fish
040900040301-01	Rivers/Streams in HUC 040900040301	Includes: Fellows Creek, Green Drain, Ingall Drain, North Branch Fellows Creek, South Branch Fellows Creek and Truesdell Drain	Water
040900040406-01	Rivers/Streams in HUC 040900040406	Includes: Ashcroft-Sherwood Drain, Rouge, River and Shaw Drain	Water
040900040407-01	Rivers/Streams in HUC 040900040407	Includes: Rouge, River	Water
040900050102-07	MIDDLE STRAITS LAKE	W. of W. Bloomfield.	Fish
040900050102-08	UNION LAKE	7 miles SW of Pontiac.	Fish
040900050104-02	WHITE LAKE	SW of White Lake.	Fish
040900050105-04	UPPER PROUD LAKE	W. of W. Bloomfield. Proud Lake State Recreation Area.	Fish
040900050203-03	FOUR MILE LAKE	West of Dexter and NE of Chelsea in the Chelsea State Game Area.	Fish
040900050301-02	WHITMORE LAKE	Vicinity of Whitmore Lake.	Fish
040900050303-01	Rivers/Streams in HUC 040900050303	Includes: Honey Creek and Unnamed Tributary to Honey Creek	Water
040900050303-03	Rivers/Streams in HUC 040900050303	Includes: HONEY CREEK	Water
040900050306-10	SOUTH LAKE	N. of Lyndon Center.	Fish
040900050307-12	BISHOP LAKE	Brighton State Recreation Area.	Fish
040900050307-18	Chenango Lake	Entire Lake	Fish
040900050308-02	SECOND SISTER LAKE	W. of Ann Arbor.	Fish

AUID	Assessment Unit Name	Location Description	Source of Impairment
040900050403-01	UNNAMED LAKE	S. of Ford Lake in the NE corner of Sec. 26, T3S, R7E (Textile Road and Burton Road).	Fish
040900050407-01	Rivers/Streams in HUC 040900050407	Includes: WAGNER-PINK DRAIN	Water
040900050407-02	Rivers/Streams in HUC 040900050407	Includes: Huron River, Bancroft Noles Drain, Brook Drain, Hale Drain, Regan Drain, Vandecar Drain, Unnamed Tributary to Huron River, and Warner Drain	Water
040900050407-03	Rivers/Streams in HUC 040900050407	Includes: Huron River	Water
040900050407-04	Rivers/Streams in HUC 040900050407	Includes: Huron River	Water
040900050407-05	Rivers/Streams in HUC 040900050407	Includes: Baker and Green Drain, Port Creek, Unnamed Tributary to Port Creek, and Van Hountin Drain	Water
041000010107-01	Rivers/Streams in HUC 041000010107	Includes: AMOS PALMER DRAIN, N. BR.	Water
041000010107-02	Rivers/Streams in HUC 041000010107	Includes: Stony Creek including Tributaries	Water
041000010107-03	Rivers/Streams in HUC 041000010107	Includes: Ross Drain	Water
041000010201-01	Rivers/Streams in HUC 041000010201	Includes: PLUM CREEK	Water
041000010302-01	Rivers/Streams in HUC 041000010302	Includes: HALFWAY CREEK	Water
041000020101-03	CLARK LAKE	NW of Brooklyn.	Fish
041000020106-02	SAND LAKE	8 miles west of Clinton off US-12.	Fish
041000020106-03	WAMPLERS LAKE	Vicinity of Oak Shade Park.	Fish
041000020202-01	Rivers/Streams in HUC 041000020202	Includes: Cadmus Drain, Harrison Drain, Nash Drain, South Branch River Raisin, Stony Creek, Unnamed Tributary to Harrison Drain, and Unnamed Tributaries to South Branch River Raisin	Water
041000020302-01	Rivers/Streams in HUC 041000020302	Includes: Bear Creek	Water
041000020302-02	Rivers/Streams in HUC 041000020302	Includes: Bear Creek	Water

AUID	Assessment Unit Name	Location Description	Source of Impairment
041000020302-03	Rivers/Streams in HUC 041000020302	Includes: Camp Drain, J B Drain, Hudson Lake from the outlet upstream to include Bear Creek, Hennings Drain, Tucker Drain, and Unnamed Tribs	Water
041000020302-05	Rivers/Streams in HUC 041000020302	Includes: Baker and May Drain, Hoadley Drain, and Unnamed Tributaries to Baker and May Drain	Water
041000020302-06	Rivers/Streams in HUC 041000020302	Includes: Rice Lake Drain	Water
041000020306-01	Rivers/Streams in HUC 041000020306	Includes: Big Meadow Drain, Grinnel Drain, Bixby Drain, and Unnamed Tribs	Water
041000020306-02	Rivers/Streams in HUC 041000020306	Includes: Unnamed Tributary to Big Meadow Drain	Water
041000020306-03	Rivers/Streams in HUC 041000020306	Includes: Big Meadow Drain	Water
041000020310-01	Rivers/Streams in HUC 041000020310	Includes: River Raisin	Fish
041000020404-01	Rivers/Streams in HUC 041000020404	Includes: MACON CREEK	Water
041000020410-01	Rivers/Streams in HUC 041000020410	Includes: Barnaby Drain, Brost Drain, Brown Drain, Burdeau Drain, Karm Drain, Mason Run, Middle Branch Willow Run, Moore Drain, North Branch Willow Run, River Raisin, Sietz Drain, Unnamed Tributary to River Raisin, and Willow Run	Water
041000020410-02	Rivers/Streams in HUC 041000020410	Includes: River Raisin and Unnamed Tributary to River Raisin	Water
041000020410-03	Rivers/Streams in HUC 041000020410	Includes: River Raisin and Unnamed Tributary to River Raisin	Water
041000060106-01	Rivers/Streams in HUC 041000060106	Includes: BEAN CREEK	Water
041000060106-02	Rivers/Streams in HUC 041000060106	Includes: BEAN CREEK	Water
041000060106-03	Rivers/Streams in HUC 041000060106	Includes: MEDINA DRAIN	Water

APPENDIX B.
POINT SOURCES WITH NPDES PERMIT LIMITATIONS FOR MERCURY

Facility Name	Permit No.	Monitoring Point	Permitted Flow (Million Gallons Per Day)
Adrian WWTP	MI0022152	001A	7
Albion WWTP	MI0022161	001A	4
Allegan WWTP	MI0020532	001A	1.2
Alma WWTP	MI0020265	001A	2.5
Alpena WWTP	MI0022195	001A	5.5
Ann Arbor WWTP	MI0022217	001A	29.5
Battle Creek WWTP	MI0022276	001A	18
Bay City WWTP	MI0022284	004A	12
Benton Harbor-St Joseph WWTP	MI0022322	001A	15.3
Berlin Twp WWTP	MI0020826	001A	1.8
Big Rapids WWTP	MI0022381	001A	2.4
Bridgeport Twp WWTP	MI0022446	001A	3.41
Brighton WWTP	MI0020877	001A	2.25
Buchanan WWTP	MI0022489	001A	1.5
Buena Vista Twp WWTP	MI0022497	001A	2.2
Cadillac WWTP	MI0020257	001A	3.2
Carbon Green Bioenergy	MI0057989	001A	0.184
Caro WWTP	MI0022551	001A	1.2
Cass City WWTP	MI0022594	001A	1
Charlotte WWTP	MI0020788	001A	1.8
Cheboygan WWTP	MI0020303	001A	2.5
Coldwater WWTP	MI0020117	001A	3.2
Copper Range Co	MI0006114	001A	12
Copperwood Mine	MI0058969	001A	0.504
Croswell WWTP	MI0021083	001A	0.5
Dearborn Ind Generation Plt	MI0056235	006C	241
Dearborn Ind Generation Plt	MI0056235	04B0	241
DECO-Belle River Plt	MI0038172	002A	0.3836
DECO-Fermi-2 Plt	MI0037028	011A	0.216
DECO-Greenwood Plt	MI0036978	001A	17
Delhi Twp WWTP	MI0022781	001A	4
Delta Twp WWTP	MI0022799	001A	6
Detroit WWTP	MI0022802	050A	830
Dowagiac WWTP	MI0022837	001A	2.5
E B Eddy Paper Inc	MI0002160	008A	1.6
East Lansing WWTP	MI0022853	001A	18.75
Eaton Rapids WWTP	MI0022861	001A	1.2

Federal Mogul Corp-Greenville	MI0002836	002A	1.2
Fibrek-Menominee	MI0053601	001A	4
Flint WWTP	MI0022926	001A	50
Flushing WWTP	MI0020281	001A	3
Frankenmuth WWTP	MI0022942	001A	1.8
Galien River SD Auth WWTP	MI0027987	001A	3
Genesee Co #3 WWTP	MI0022993	001A	11
Genesee Co-Ragnone WWTP	MI0022977	001B	60
Gerdau MacSteel-Jackson	MI0028461	001A	0.15
Gladwin WWTP	MI0023001	001A	0.65
Gogebic-Iron WW Authority WWTP	MI0020125	001A	3.4
Grand Haven BL&P-J B Sims	MI0000728	003A	0.052
Grand Haven BL&P-J B Sims	MI0000728	002A	0.4
Grand Haven BL&P-J B Sims	MI0000728	005A	67
Grand Haven-Spring Lake WWTP	MI0021245	001A	6.67
Grand Ledge WWTP	MI0020800	001A	1.5
Grand Rapids WWTP	MI0026069	001A	61.1
Grandville WWTP	MI0023027	001A	4.4
Greenville WWTP	MI0020397	001A	1.5
Guardian Ind-Carleton Plant	MI0037001	001A	0.546
Gun Lake WWTP	MI0042501	001A	1.2
Hartford WWTP	MI0023094	001A	0.35
Hastings WWTP	MI0020575	001A	2
Hemlock Semiconductor Corp	MI0027375	002A	1.5
Hillman Power Company	MI0044563	001A	0.15
Hillsdale WWTP	MI0022136	001A	2
Holland WWTP	MI0023108	001A	12
Holland WWTP	MI0023108	002A	12
Holland WWTP	MI0023108	003A	12
Holly WWTP	MI0020184	001A	1.35
Howell WWTP	MI0021113	001A	2.45
Ionia WWTP	MI0021041	001A	4
Iron Mountain-Kingsford WWTP	MI0023205	001A	3.3
Ishpeming Area WWTP	MI0044423	001A	2.34
Jackson WWTP	MI0023256	001A	19
Kalamazoo Lake WWTP	MI0056324	001A	1
Kalamazoo WWTP	MI0023299	001A	53.5
Kennecott-Humboldt Mill	MI0058649	001A	0.82
KI Sawyer WWTP-Marquette Co	MI0021423	001A	0.65
Kinross Twp WWTP	MI0057776	001A	1.2

Lacks Enterprises Inc-GWCU	MI0057849	001A	0.35
Lanse WWTP	MI0020133	001A	0.72
Lapeer WWTP	MI0020460	001A	2.3
Leoni Twp WWTP	MI0045942	001A	3
Leoni Twp WWTP	MI0045942	001A	3
Lowell WWTP	MI0020311	001A	1.42
Ludington WWTP	MI0021334	001A	7.5
Manchester WWTP	MI0023507	001A	0.55
Manistee WWTP	MI0020362	001A	1.3
Manistique Papers Inc	MI0003166	005A	8
Manistique Papers Inc	MI0003166	006A	8
Manistique WWTP	MI0023515	001A	1.5
Marlette WWTP	MI0021024	001A	0.62
Marquette Co-Solid Waste LF	MI0056171	001A	0.002367123
Marquette WWTP	MI0023531	001A	3.85
Marshall WWTP	MI0023540	001A	3
Mason WWTP	MI0020435	001A	1.5
MDEQ-RRD-Ott/Story SF	MI0053309	001A	1.728
Menominee WWTP	MI0025631	001A	3.2
Mich Pwr LP	MI0053767	001A	0.7752
Mich South Cen Power Agency	MI0039608	002A	0.5674
Midland WWTP	MI0023582	001A	10
Milan WWTP	MI0021571	001A	2.5
Mt Pleasant WWTP	M00023655	001A	4.14
Muskegon Co WWMS Metro WWTP	MI0027391	002A	4.2
Muskegon Co WWMS Metro WWTP	MI0027391	001A	43
Negaunee WWTP	MI0021296	001A	1.2
New Baltimore WWTP	MI0023680	001A	1.75
New Page Corp-Escanaba Paper Co	MI0000027	001A	50
Niles WWTP	MI0023701	001A	5.8
Norway WWTP	MI0020214	001A	0.5
OmniSource-Bay City	MI0058884	001A	0.05
Orchard Hill LF-Watervliet	MI0058853	001A	0.05
Owosso/Mid Shiawassee Co WWTP	MI0023752	001A	6
Paw Paw Lake Area WWTP	MI0023779	001A	2.2
Penda Corporation-Lapeer	MI0055972	001A	0.02
Pinconning WWTP	MI0020711	001A	0.5
Plainwell WWTP	MI0020494	001A	1.3
Pontiac WWTP	MI0023825	001A	30.6
Reed City WWTP	MI0020036	001A	0.95

Richmond WWTP	MI0023906	001A	0.9
Rockwood WWTP	MI0021181	001A	1
Rollin-Woodstock WWTP	MI0027669	001A	1.2
Romeo WWTP	MI0021679	001A	2.1
Saginaw Twp WWTP	MI0023973	001A	6.5
Saginaw Twp-Center Rd LF	MI0054739	004A	0.024
Saginaw WWTP	MI0025577	001A	32
Saline WWTP	MI0024023	001A	1.81
Sandusky WWTP	MI0020222	001A	0.95
Severstal Dearborn LLC	MI0043524	004C	5.1
Severstal Dearborn LLC	MI0043524	002A	14
Severstal Dearborn LLC	MI0043524	004D	26
Severstal Dearborn LLC	MI0043524	04E0	30
Severstal Dearborn LLC	MI0043524	001A	102
Severstal Dearborn LLC	MI0043524	006A	150
Severstal Dearborn LLC	MI0043524	004B	348
South Haven WWTP	MI0020320	001A	2.19
South Lyon WWTP	MI0020273	001A	2.5
St Johns WWTP	MI0026468	001A	1.9
St Louis WWTP	MI0021555	001A	1.6
Standish WWTP	MI0024139	003A	0.65
Stone Container	MI0006122	001A	11.95
Sturgis WWTP	MI0020451	002A	2.8
Tawas Utility Authority WWTP	MI0021091	001A	2.4
Tecumseh WWTP	MI0020583	001A	1.61
Three Rivers WWTP	MI0020991	001A	2.75
Vassar WWTP	MI0024252	001A	0.7
Verso Paper Corp-Quinnesec	MI0042170	001A	22.5
Warren WWTP	MI0024295	001B	36
West Bay Co Regional WWTP	MI0042439	001A	10.28
West Branch WWTP	MI0020095	001A	0.7
West Iron Co SA WWTP	MI0043281	001A	2
Wolverine Power Supply-Vandyke	MI0004162	001A	0.104
Wyoming WWTP	MI0024392	001A	22
YCUA Regional WWTP	MI0042676	001A	46
YCUA Regional WWTP	MI0042676	003A	51.2
Zeeland WWTP	MI0020524	001A	1.65

APPENDIX C. 2002 AIR EMISSIONS

Source Record Number (SRN)	Category in Emissions Inventory (EI)	Facility Name	Pounds Mercury/yr (2002)
A4750	Auto Shredder	FERROUS PROCESSING AND TRADING CO. (SLC RECYCLING)	0.4
B3240	Auto Shredder	FRITZ ENTERPRISES INC	1
A2457	Auto Shredder	LOUIS PADNOS IRON & METAL	5.6
N0844	Auto Shredder	Rifkin Scrap Iron and Metal Company	2.7
N6293	Auto Shredder	STRONG STEEL PRODUCTS LLC	1
B1982	Auto Shredder	Louis Padnos Iron & Metal	Not Available
B2281	Auto Shredder	JACKSON IRON & METAL	Not Available
B4372	Auto Shredder	OmniSource Sturgis	Not Available
B4884	Auto Shredder	PADNOS SUMMIT STEEL	Not Available
B7634	Auto Shredder	WEST MICHIGAN IRON & METAL	Not Available
N1340	Auto Shredder	Portland Iron & Metal Inc	Not Available
N1373	Auto Shredder	KALAMAZOO METAL RECYCLERS	Not Available
N3753	Auto Shredder	EAST KINGSFORD IRON & METAL	Not Available
N6823	Auto Shredder	SPOONER METALS LLC	Not Available
B1743	Cement Manufacturing	HOLCIM (US) INC.	80
B1477	Cement Manufacturing	LAFARGE MIDWEST INC.	582
B1559	Cement Manufacturing	St. Marys Cement, Inc. (U.S.)	32
A7809	Coke Production	U S STEEL GREAT LAKES WORKS (coke)	2.6
B2178	Cupola	Cadillac Casting, Inc	24.5
B1909	Cupola	CWC Textron	6
A0767	Cupola	East Jordan Iron Works	33.5
B1991	Cupola	GM POWERTRAIN GROUP - SAGINAW METAL CASTING	26.5
A3934	Cupola	Great Lakes Castings LLC	13.5
B1577	Cupola	GREDE LLC - IRON MOUNTAIN	16.5
A4302	Cupola	MAHLE industries Inc.	3.5
B2043	Cupola	Metavation Vassar, LLC (Grede in '02)	16
B2404	Cupola	Robert Bosch LLC	15.5
B1961	Cupola	Rothbury Steel, Inc.	2
N5795	Cupola	Sparta Foundry, Inc.	12
B2022	Cupola	Sturgis Foundry Corporation	3
B2658	Dental Amalgam	Kerr Corporation	4
A6177	EAF (Grey Iron)	EATON CORP	1.2
B1547	EAF (Grey Iron)	Hayes-Albion Corporation	6
N5814	EAF and EIF (Grey Iron)	ASAMA COLDWATER MANUFACTURING, INC.	10.3
B2836	Electrical Utility (Coal Combustion)	B. C. Cobb Plant	84.7

Source Record Number (SRN)	Category in Emissions Inventory (EI)	Facility Name	Pounds Mercury/yr (2002)
B2840	Electrical Utility (Coal Combustion)	Consumers Energy Karn-Weadock Facility	215
B2815	Electrical Utility (Coal Combustion)	Detroit Edison Harbor Beach Power Plant	8.7
B2810	Electrical Utility (Coal Combustion)	DETROIT EDISON RIVER ROUGE	120
B2811	Electrical Utility (Coal Combustion)	DETROIT EDISON TRENTON CHANNEL	200
B2816	Electrical Utility (Coal Combustion)	Detroit Edison Monroe Power	620
B1573	Electrical Utility (Coal Combustion)	Escanaba Power Plant	36
B2357	Electrical Utility (Coal Combustion)	Holland BPW, Generating Station & WWTP	7.1
B2835	Electrical Utility (Coal Combustion)	J. H. Campbell Plant	317.6
B1976	Electrical Utility (Coal Combustion)	J.B. Sims Generating Station	16
B2846	Electrical Utility (Coal Combustion)	J.R. WHITING CO	70.8
B2647	Electrical Utility (Coal Combustion)	LBWL, Eckert & Moores Park Station	102.3
B4001	Electrical Utility (Coal Combustion)	LBWL, Erickson Station	27.7
B1833	Electrical Utility (Coal Combustion)	MARQUETTE BOARD OF LIGHT & POWER	18
B6611	Electrical Utility (Coal Combustion)	MI SO CENTRAL POWER AGENCY	13
B2796	Electrical Utility (Coal Combustion)	ST. CLAIR / BELLE RIVER POWER PLANT	561
N1685	Electrical Utility (Coal Combustion)	TES Filer City Station	5.4
B4261	Electrical Utility (Coal Combustion)	WISCONSIN ELECTRIC POWER COMPANY	18.5
B2132	Electrical Utility (Coal Combustion)	WYANDOTTE DEPT MUNI POWER PLANT	11.2
B2840	Electrical Utility (Oil Combustion)	Consumers Energy Karn-Weadock Facility (oil)	3.55
B2816	Electrical Utility (Oil Combustion)	Detroit Edison Monroe Power	1.20163
B6611	Electrical Utility (Oil Combustion)	MI SO CENTRAL POWER AGENCY	39.9331
B2796	Electrical Utility (Oil Combustion)	ST. CLAIR / BELLE RIVER POWER PLANT	1.20329
N1395	Electrical Utility (Wood Fired)	Cadillac Renewable Energy Facility	1.9451

Source Record Number (SRN)	Category in Emissions Inventory (EI)	Facility Name	Pounds Mercury/yr (2002)
N2388	Electrical Utility (Wood Fired)	GRAYLING GENERATING STATION LTD PTNR	1.4822
N1266	Electrical Utility (Wood Fired)	HILLMAN POWER CO	1.0626
N5549	Flourescent Lamp Recycler	GREENLITES LAMP RECYCLING	1.55
N5948	Flourescent Lamp Recycler	GREENLITES LAMP RECYCLING	1.5
N6821	Flourescent Lamp Recycler	Reliable Relamping Inc	0.19
N5614	Flourescent Lamp Recycler	VALLEY CITY DISPOSAL INC	see N5942
N5941	Flourescent Lamp Recycler	VALLEY CITY DISPOSAL INC	0.231
N5942	Flourescent Lamp Recycler	VALLEY CITY DISPOSAL INC	see N5942
A4033	Hazardous Waste Incineration	The Dow Chemical Company U.S.A., Midland	11
M4139	Hospital Waste Incineration	MEDICAL WASTE SERVICES LLC	3
A0884	Industrial/Commercial (coal combustion)	ESCANABA PAPER COMPANY	15.4346
B7192	Industrial/Commercial (coal combustion)	INTERNATIONAL PAPER	1.2268
A0884	Industrial/Commercial (wood combustion)	ESCANABA PAPER COMPANY	1.31776
B7192	Industrial/Commercial (wood combustion)	INTERNATIONAL PAPER (wood)	1.49969
B2169	Lime Manufacturing	CARMEUSE LIME Inc, RIVER ROUGE OPERATION	26.9
B3520	Lime Manufacturing	CARMEUSE/DETROIT LIME	27.4
B1846	Lime Manufacturing	Occidental Chemical Corporation ((Dow Chemical in '02)	19.5
M4148	Municipal Waste Incineration	DETROIT RENEWABLE POWER, LLC	38
N1125	Municipal Waste Incineration	JACKSON COUNTY RESOURCE RECOVERY FACILITY	6
N1604	Municipal Waste Incineration	Kent County Waste to Energy Facility	21
A9831	Petroleum Refining	MARATHON PETROLEUM COMPANY LP	4.14
B2103	Sewage Sludge Incineration	DETROIT WWTP	226
B1598	Sewage Sludge Incineration	FLINT WATER POLLUTION CONTROL FACILITY	9

Source Record Number (SRN)	Category in Emissions Inventory (EI)	Facility Name	Pounds Mercury/yr (2002)
B1950	Sewage Sludge Incineration	PONTIAC WWTP	5
L0058	Sewage Sludge Incineration	PORT HURON WWTP	2
B1792	Sewage Sludge Incineration	Warren Waste Water Treatment Plant	12
B6237	Sewage Sludge Incineration	YPSILANTI COMM. UTILITIES AUTHORITY	32
B1754	Steel Foundry	ERVIN AMASTEEL DIVISION	71
B1991	Steel Foundry	GM POWERTRAIN GROUP - SAGINAW METAL CASTING	206
B1929	Steel Foundry	MICHIGAN STEEL, INC.	5
A8640	Steel Manufacturing (Basic Oxygen Furnaces)	SEVERSTAL DEARBORN LLC	76
A7809	Steel Manufacturing (Basic Oxygen Furnaces)	U S STEEL GREAT LAKES WORKS	320
B7061	Steel Manufacturing (Electric Arc Furnaces)	Gerdau MacSteel Monroe	13
B4306	Steel Manufacturing (Electric Arc Furnaces)	Gerdau Special Steel North America - Jackson Mill	18
N5886	Switch Manufacturer	MERCURY DISPLACEMENT INDUSTRIES	148
B1827	Taconite Processing	EMPIRE IRON MINING PARTNERSHIP	16
B4885	Taconite Processing	TILDEN MINING COMPANY LC	72