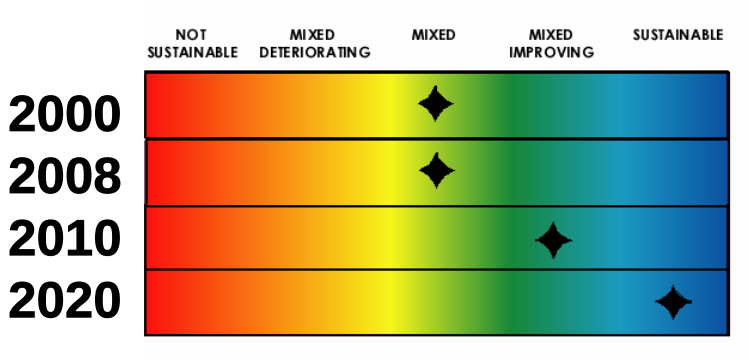
Subgoal 7
Are sediments, air, land, and water sources or pathways of contamination that affect

What is our target for sustainability?

A basin where remedial action needs have been accomplished and materials in use are the least harmful to the environment and are used and disposed of in an environmentally sensitive manner in the basin and around the world.

Lake Michigan Target Dates for Sustainability



Why is this important?

Pollutants are transported via different pathways leading to multiple approaches needed to address pollutant sources. The Lake Michigan Mass Balance Study has made a detailed examination of four categories of pollutants and their impacts on pollutant loading on the lake. The findings of the study allow decision-makers to better understand pollution pathways and adopt policies to address pollutant sources.

What is the current status?

- **PCBs.** PCB concentrations in fish over the past 30 years show a downward trend from peak levels in the 1970s for all media. Atmospheric deposition is the major current route of PCBs to the lake (from sources inside and outside the basin) with the Chicago area being a significant source of atmospheric PCBs. The most recent data also exhibit a decline, however, this indicates that the rate of decline is slowing and concentrations in lake trout remain above desired levels.
- **Mercury.** The current major source of mercury to the lake is from atmospheric deposition. Modeling results suggest that a significant amount of the existing mercury settling out of water is being recycled back into the system. Most Lake Michigan lake trout and coho salmon exceed the USEPA guidelines for unrestricted consumption.
- **Atrazine.** Observed and forecasted lake-averaged concentrations of atrazine are well below USEPA biological effects thresholds with tributaries serving as the major transporter of atrazine runoff from agricultural fields to the lake. Atrazine is very persistent in Lake Michigan with decay estimated at less than 1% per year and concentrations forecasted to increase in the lake under present loads (1994-1995 constant load).
- **Phosphorus.** Tributaries are the major source of phosphorus to Lake Michigan, but Lake Michigan open lake phosphorus loads and concentrations are low and below GLWQA and IJC targets. Highest concentrations can be observed in selected nearshore zones near tributary mouths and in Green Bay.
- **Urban Runoff.** An increase in urbanization is leading to an increase in nonpoint source runoff in the basin. Many cities, however, are working to reduce the impacts of runoff through pollution prevention programs and stormwater retrofits and implementation of Phase II of the Stormwater regulations.
- **Agricultural Runoff.** The Lake Michigan basin has a high concentration of agricultural enterprises where animals are kept and raised in confined environments. Polluted runoff from animal feeding operations is a leading source of water pollution in some watersheds.
- **Areas of Concern.** Areas of Concern have seen significant strides in remediation, although none of the lake Michigan basin AOCs have been delisted. Work is currently focused on a BUI by BUI approach with Manistique the first to delist a BUI.
- **Climate Change.** Temperatures impact on pollutants and their interaction with the aquatic environment

What are the major challenges?

- Impacts of climate change
- Lack of comprehensive understanding of pollutant movement and remediation makes the goal of reaching sustainability by 2020 difficult
- Impacts of increased global mercury emissions
- Increasing monitoring of existing and emerging stressors on the lake
- Need to set delisting targets for Areas of Concern and resources to implement cleanup actions

What are the next steps?

- Develop a better understanding of the natural dynamics that affect pollutant distribution in the Lake Michigan ecosystem and why near shore and open lake can have wide variances.
- Reduce pollutant loads with effective pollution control measures with a focus on nutrients and mercury.
- Build on the coordinated monitoring of 2005 and develop a 10-year trend analysis based on the 1994-95 mass balance project.
- Review contaminated sediment sites and their status and update the status of the Legacy Act funding or delisting opportunities.
- Research nutrient contributions from the agricultural sector and nonpoint sources during wet weather and determine if nutrient levels are linked to *Cladophora* blooms.
- Develop Impaired Waters Strategy.
- Promote phase-out of grandfathered in PCB use in equipment, and phosphorus in detergents, and fertilizers.

What are some tools for addressing the challenges?

- Nitrogen Removal
- Catalog of Federal Funding Sources for Watershed Protection and Nonpoint Source Control

What are the State of the Lakes Ecosystem (SOLEC) indicators used to help assess the status of the subgoal?

Indicator # 111 - Phosphorus Concentrations and Loadings
Lake Michigan Status: Open Lake - Good; Nearshore – Poor; Trend: Open Lake - Improving; Nearshore - Undetermined
Indicator # 114 - Contaminants in Young-of-the-Year Spottail Shiners
Lake Michigan Status: Not Assessed; Trend: Not Assessed
Indicator # 115 - Contaminants in Colonial Nesting Waterbirds
Lake Michigan Status: Mixed; Trend: Improving
Indicator # 117 - Atmospheric Deposition of Toxic Chemicals
Status: Mixed; Trend: Improving (for PCBs, banned organochlorine pesticides, dioxins and furans) / Unchanging or slightly improving (for PAHs and mercury)
Indicator # 118 - Toxic Chemical Concentrations in Offshore Waters
Lake Michigan Status: Fair; Trend: Undetermined
Indicator # 119 - Concentrations of Contaminants in Sediment Cores
Status: Mixed Trend: Improving/Undetermined
Indicator # 121 - Contaminants in Whole Fish
Lake Michigan Status: Fair; Trend: Improving
Indicator # 124 - External Anomaly Prevalence Index for Nearshore Fish
Indicator # 4177 - Biological Markers of Human Exposure to Persistent Chemicals
Lake Michigan Status: Not Assessed; Trend: Undetermined
Indicator # 4201 - Contaminants in Sport Fish
Lake Michigan Status: Mixed; Trend: Improving
Indicator # 4202 - Air Quality
Status: Mixed; Trend: Improving
Indicator # 4501 - Coastal Wetland Invertebrate Community Health
Status: Not Assessed; Trend: Not Assessed
Indicator # 4502 - Coastal Wetland Fish Community Health
Status: Mixed; Trend: Improving
Indicator # 4506 - Contaminants in Snapping Turtle Eggs
Status: Mixed; Trend: Undetermined
Indicator # 7028 - Sustainable Agriculture Practices
Status: Not Assessed; Trend: Not Assessed
Indicator # 7061 - Nutrient Management Plans
Status: Not Assessed; Trend: Not Assessed
Indicator # 7062 - Integrated Pest Management
Status: Not Assessed; Trend: Not Assessed
Indicator # 7064 - Vehicle Use
Status: Poor; Trend: Deteriorating
Indicator # 7065 - Wastewater Treatment and Pollution
Status: Not Assessed; Trend: Undetermined
Indicator # 8135 - Contaminants Affecting Productivity of Bald Eagles
Status: Mixed; Trend: Improving
Indicator # 9000 - Acid Rain
Status: Mixed; Trend: Improving

For more information on status of indicators, see http://www.epa.gov/solec/sogl2007/

Lake Michigan Mass Balance Project

What It Tells Us

The Lake Michigan Mass Balance (LMMB) Project is an enhanced monitoring and modeling project that is working to develop a scientific base of information to inform LaMP policy decisions and better understand the science of pollutants within an ecosystem (USEPA 1995; 1997a; 1997b; 1997c; 1997d; 1997e; Richardson et al. 1999; USEPA 2001d) . The LMMB Project's specific objectives are:

- To identify relative loading rates of four categories of pollutants (PCBs, mercury, trans-nonachlor, and atrazine) entering Lake Michigan from major media (air, tributaries, and sediments);
- To establish baseline loading estimates in 1994-95 against which to gauge future information;
- To develop the predictive ability through the use of models to determine the environmental benefits of specific load reduction scenarios for toxic substances and the time required to realize those benefits;
- To improve our understanding of key environmental processes governing the movement of pollutants through and out of the lake (cycling) and fish and plant life (bioavailability) within this large freshwater ecosystem; and
- In addition, 11 tributary mouths were sampled for nutrients.

The LMMB Project focused on sampling and constructing mass balance models for a limited group of pollutants. Polychlorinated biphenyls (PCBs), atrazine, phosphorus, trans-nonachlor, and mercury were selected for inclusion in the LMMB Project because these pollutants currently or potentially pose a risk to aquatic and terrestrial organisms (including humans) in the Lake Michigan ecosystem and on the LaMP pollutant lists. These pollutants were also selected to cover a wide range of chemical and physical properties and represent other classes of compounds which pose current or potential problems. Once a mass budget for selected pollutants is established and a mass balance model calibrated, additional contaminants can be modeled with sufficient data. For the LMMB Study, models were calibrated using samples collected and analyzed for such purposes by numerous partners and collaborators (Hornbuckle et al 1995; Hall and Robertson 1998; Hall et al 1998; Hawley 1999; Robbins et al 1999; Green et al 2000; Van Hoff 2000; Miller et al. 2001; USEPA 2001a; 2001b; 2001c; 2001e, 2002a, 2002b).

What It Does Not Tell Us

The data and models provide insights to the whole lake ecosystem which may not represent data in any given specific near shore area. The relationship of the near shore to the open waters remains a topic needing additional research.

Pathways of Pollution

Sediments, air, land, and water continue to be sources or pathways of contamination that affect the integrity of the Lake Michigan ecosystem. In the Lake Michigan system, pollutant inputs may come from atmospheric deposition, tributary loads, or sediments. Pollutants may leave the system through volatilization to the atmosphere, or discharge through the Straits of Mackinac. Pollutants within the system may be transformed through degradation or stored in ecosystem compartments such as the sediments, water column, or biota, including humans.

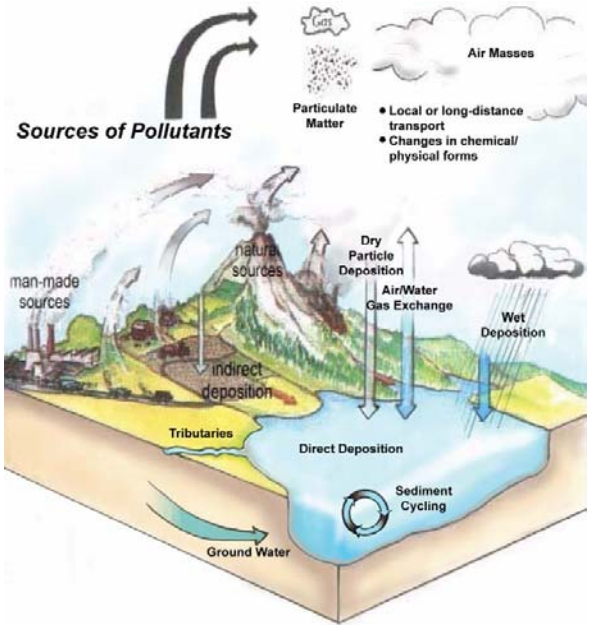


Figure 7-1 Pollutants enter and leave Lake Michigan through several pathways
Source: www.epa.gov/owow/oceans/airdep
Augmented by Joseph F. Abboreno, LaMP 2002

Lake Michigan Mass Balance Resampling Results

Five of the original eleven Lake Michigan Mass Balance tributary sampling sites were resampled in 2005-2006. The resampled sites were selected based on previously calculated loads of PCB and mercury to Lake Michigan; the resampled sites included the Lower Fox in Wisconsin, the Grand Calumet Ship Canal in Indiana, and the Kalamazoo, Grand, and St. Joseph Rivers in Michigan. Twelve (12) rounds of sampling were conducted at each of the five resampled tributary monitoring sites.

Total Mercury Loads

Reductions in calculated total mercury loads relative to the loads calculated as part of the Lake Michigan Mass Balance were observed in all five of the resampled sites (table 7-1).

Table 7-1. Calculated total mercury loads for the resampled sampling sites.

Site	Load (Kg) 1994-1995	Load (Kg) 2005-2006	Min and Max Load (Kg) Previous Years
Grand	26	10	13.5 (2002); 24.8 (1999)
Kalamazoo	17	8	7.6 (2002); 13.3 (1999)
St. Joseph	21	7	13.1 (2004); 32.1 (2001)
Grand Calumet Ship Canal	6	4.5	N/A
Fox	108	53	N/A

The Michigan Department of Environmental Quality (MDEQ) and the Michigan District office of the U.S. Geological Survey Michigan Water Science Center have been sampling the Grand, Kalamazoo, and St. Joseph Rivers for a variety of constituents, including total mercury, since about 1999. Considering the loads calculated from the available data shows how variable these numbers may be from year to year. The 1994-1995 load was nearly reached in 1999 on the Grand River. In 2001 the load from the St. Joseph river exceeded that calculated during the 1994-1995 period.

Total PCB Loads

Reductions in total PCB loads relative to those calculated as part of the Lake Michigan Mass Balance were observed at all five of the resampled sites (table 7-2).

Table 7-2. Calculated total PCB loads for the resampled sampling sites.

Site	Load (Kg) 1994-1995	Load (Kg) 2005-2006
Grand	10	6.2
Kalamazoo	39	20
St. Joseph	9.3	6.7
Grand Calumet Ship Canal	31	16
Fox	210	130

Year to year variations in flow and temperature make assessing changes in PCB loading rates a difficult proposition. Considering the dissolved fraction of PCB during winter conditions minimized the effects of the confounding factors and should offer a glimpse of the true trend in loading rates.

At the Lower Fox River, dissolved wintertime PCB concentrations have dropped from a median of about 3.5 ng/L to 1.5 ng/L. This change suggests that natural recovery and active remediation on the Lower Fox River have resulted in a reduction in wintertime PCB concentrations on the order of a factor of two in the 10 years since the completion of LMMB Project sampling.

Confounding Factors

The calculated load reductions observed for both total PCB and total mercury may indeed be genuine; however several factors suggest that the reduced loads might not be part of a larger trend, but are related to a number of confounding factors. These factors include differences between flow regimes and sampling plans. Median flows for the 2005-2006 period were lower at all sites relative to the 1994-1995 median flow values; total annual flow volumes were less than 75% of the total annual flow volumes observed during the LMMB for the Grand and Fox Rivers (table 7-3). The most dramatic difference in flow regimes was observed at the Fox River site, where the May through September monthly median flow values in 2005-2006 were up to several thousand cubic feet per second lower than the corresponding monthly median values in 1994-1995.

Table 3. Median flows and comparison of total flow volumes for the resampled LMMB tributary monitoring sites.

Site	1994-1995 (cfs)	2005-2006 (cfs)	% of 1994-1995 Flow Volume
Grand	4360	2838	72.4 %
Kalamazoo	1990	1510	99.5 %
St. Joseph	4100	3006	106 %
Grand Calumet Ship Canal	459	407	89.0 %
Fox	3500	3360	74.1 %

Although the median flow values are consistently lower for the 2005-2006 period relative to the 1994-1995 period, the extreme high flows were larger for the 2005-2006 period at the Kalamazoo, St. Joseph, and Grand Calumet sites (table 7-4). Since an appreciable portion of the total mercury and total PCB load is driven by resuspension of contaminated sediment, the higher ten percent exceedance flows might offset the effect of the lower median flow values for these sites.

Table 7-4. Ten percent exceedance flows for the resampled tributary monitoring sites.

Site	1994-1995 (cfs)	2005-2006 (cfs)
Grand	8640	8131
Kalamazoo	**2900**	**3620**
St. Joseph	**5900**	**8255**
Grand Calumet Ship Canal	**486**	**525**
Fox	6970	5350

Budgetary constraints limited each of the five resampled sites to twelve (12) rounds of sampling. Numerical experiments using suspended sediment data from the Lake Michigan Mass Balance confirm that calculating loads using a smaller pool of observations decrease both the accuracy and precision of the load estimate (table 7-5). This makes detection of trends much more difficult.

Table 7-5. Example of reduction in accuracy and precision of load estimate given a reduced level of sampling effort.

Sampling Scheme	Computed Load and 95% Confidence Interval
ALL DATA (n=222):	*128,700 MT ± 7,300*
MONTHLY DATA (n=12), 1st of month:	118,500 MT ± 34,800
MONTHLY DATA (n=12), mid-month:	85,800 MT ± 13,800
MONTHLY DATA (n=12), high-flow events:	141,100 MT ± 43,900

Conclusions

Reductions in calculated loads of both total mercury and total PCB relative to the loads calculated as part of the Lake Michigan Mass Balance were observed in all five of the resampled sites. Hydrologic conditions at the Kalamazoo, St. Joseph, and Grand Calumet sites suggest that the observed reductions in load are partly due to real changes in watershed loading rates. It has been suggested that the half-life for PCB in the Lower Fox River is between 7 and 14 years. Unfortunately, in order to detect even such a change as this given the confounding factors will require more sampling, or the passage of more time in order that the effect size increases.

The LMMB Study used an integrated, multimedia mass balance modeling approach (USEPA 1995; 1997a; Richardson et al. 1999) to evaluate the sources, transport, and fate of contaminants in the Lake Michigan ecosystem. The modeling framework is a series of coupled and/or linked models which integrates the physical, chemical, and biological components of the system and accounts for the dynamic interactions and processes in the system. The mass balance approach is based upon the principle of conservation of mass, which states that the mass of a chemical contained in the lake is equal to the amount entering the system, less the amount leaving and chemically changed in the system. In the Lake Michigan system, pollutant inputs may come from atmospheric deposition, tributary loads, and from sediments within the system. Pollutants may leave the system through discharge through the Straits of Mackinac, permanent burial in bottom sediments, and volatilization to the atmosphere. Pollutants within the system may be transformed through degradation or stored in the ecosystem compartments such as the sediment, water column, or biota, including humans.

The mass balance models rely on data and output from multiple sources and were compiled into a LMMB Study database (USEPA 2001e). Computational transport includes a hydrodynamic model for advective/dispersive transport and temperature and a surface wave model for wave direction, height, and period; both use meteorological data for input. The mass balance components include sediment transport, eutrophication, and contaminant transport and fate. These models integrate atmospheric deposition and tributary mass loadings. The food web models receive chemical exposure concentrations and bioavailability (chemical concentration in phytoplankton) from the mass balance models and are used to simulate and forecast contaminant concentrations in the food web.

The modeling construct was applied to the study contaminants, where appropriate, and used three different spatial resolutions. Modeling results will be provided for each of the contaminants at the highest resolution that is presently available. The mass balance was primarily designed to provide a lakewide perspective of contaminant sources, fate, transport and effects. However, with the present spatial resolution design, selected aspects of the contaminants can be addressed on a finer scale. Information regarding Lake Michigan tributaries will be provided from samples collected only from tributary mouths.

Lake Michigan PCBs

Polychlorinated biphenyls (PCBs) are a class of manmade, chlorinated, organic chemicals that include 209 congeners, or specific PCB compounds. The highly stable, nonflammable, non-conductive properties of these compounds made them useful in a variety of products including electrical transformers and capacitors, plastics, rubber, paints, adhesives, and sealants. PCBs were produced for such industrial uses in the form of complex mixtures under the trade name “Arochlor” and were commercially available form 1930 through 1977, when the USEPA banned their production due to environmental and public health concerns (2001b).

PCB concentrations in fish over the past 30 years (USEPA 2002a) show a downward trend from peak levels in the 1970s. The most recent data also exhibit a decline, however, this indicates that the rate of decline is slowing and concentrations in lake trout remain above desired levels. Similar trends are occurring for other species. Declining concentrations (IADN 2000; USEPA 2001b; 2001e; 2002a) are also observed for other media. Although PCB concentrations have been dramatically reduced in all media since the 1970s, PCBs continue to bioaccumulate above desired levels in fish as well as other species. The LMMB Study was undertaken, in part, to investigate this problem in detail and to develop mathematical models that could be used to project future concentrations in water, sediment, and biota, with and without future remedial and/or regulatory efforts (USEPA 1995; 1997a; Richardson et al. 1999; USEPA 2001d).

LMMB Major Findings: PCBs

- Forecasted PCB concentrations in lake trout may permit unlimited consumption as early as 2039 at Sturgeon Bay and 2044 at Saugatuck.
- PCB trends indicate that concentrations are declining in all media.
- Atmospheric deposition is the major current route of PCBs to the lake (from sources inside and outside the basin).

- Chicago urban area is a substantial atmospheric source of PCBs to Lake Michigan.
- There is a dynamic interaction among water, sediments, and the atmosphere where large masses of PCBs from sediments cycle into and out of the lake via the atmosphere as vapor phase.

Lake Michigan Atrazine

Atrazine is one of the chloro-triazines, which also include simazine and cyanazine. Atrazine is a widely used herbicide for control of broadleaf and grassy weeds in corn, sorghum, rangeland, sugarcane, macadamia orchards, pineapple, turf grass sod, forestry, grasslands, grass crops, and roses. In the Lake Michigan basin, atrazine is used primarily on corn crops and is usually applied in the spring before or after emergence of the crop. Trade names for atrazine include Aatrex, Alazine, Crisazina, Malermais, Primatol, and Zeapos. Atrazine has been widely used in the agricultural regions of the Great Lakes basin since 1959 when it was registered for commercial use in the United States. Atrazine was estimated to be the most heavily used herbicide in the United States in 1987 to 1989 with heavy use in Illinois, Indiana, Iowa, Kansas, Michigan, Missouri, Nebraska, Ohio, Texas, and Wisconsin. Peak total annual U.S. usage of atrazine occurred in 1984 at 39.9 million kilograms. Usage has been dropping since then and was estimated at 33.8 million kilograms in 1995.

Unlike PCBs, the herbicide atrazine does not bioaccumulate in organisms but does remain in the water column. The two single-most important atrazine loads to Lake Michigan are tributaries and wet deposition (rain and snow). Decreases in loadings from the tributaries are evident starting in 1985. A decreasing trend of loadings from the atmosphere in the form of wet deposition is not as evident. All of the estimates of tributary loadings assumed that 0.6% of the applied active ingredient (atrazine) reached Lake Michigan. This 0.6% is often referred to as the Watershed Export Percentage (WEP). Tributary loadings for 1989, 1992, 1993, 1994, 1995, and 1998 were based on actual records of amounts applied per each county in the basin, and calculating what portions of the amount applied in those counties falls within a Lake Michigan Hydrologic Unit Code area that eventually drains into the lake. Tributary loading estimates for other years depicted were based on total annual U.S. usage for those years. For 1991, 1994, and 1995 wet deposition load estimates were based on actual precipitation data collect in the basin. Wet deposition loading estimates for other years were based on total annual U.S. usage for those years. Atmospheric loadings to the lake are higher in the southern portions than in the northern areas. The higher loadings in the south are likely due to the close proximity of this area to corn growing regions in the southern basin (Rygwelski et al. 1999).

LMMB Major Findings: Atrazine

- Observed and forecasted lake-averaged concentrations of atrazine are well below USEPA biological effects thresholds.
- Tributaries are the major source of atrazine to the lake.
- Atrazine is very persistent in Lake Michigan – decay is estimated at less than 1% per year.
- Atrazine concentrations are forecasted to increase in the lake under present loads (1994-1995 constant load).

Lake Michigan Mercury

Mercury is a naturally-occurring metal in the environment. Mercury is used in products such as battery cells, barometers, thermometers, switches, fluorescent lamps, and as a catalyst in the oxidation of organic compounds. Global releases of mercury to the environment are both natural and anthropogenic (caused by human activity). Sources of mercury releases include: combustion of various fuels such as coal; mining, smelting and manufacturing activities; wastewater; agricultural, animal and food wastes. As an elemental metal, mercury is extremely persistent in all media. Mercury also bioaccummulates in fish tissue. Mercury is also a possible human carcinogen and causes the following human health effects: stomach, large intestine, brain, lung, and kidney damage; blood pressure and heart rate increase, and fetus damage (USEPA 2001c). Because of the possible human and ecological effects of mercury, mercury was selected for study in the Lake Michigan Mass Balance Study as a bioaccumulative metal. The objective of the mercury investigation was to provide a mass balance for total mercury (USEPA 1995; 1997a; 1997b; 1997c; 1997d; 1997e; Richardson et al. 1999; USEPA 2001d). Methylmercury was not directly measured for the LMMB Study, however, some information on this parameter will be discussed.

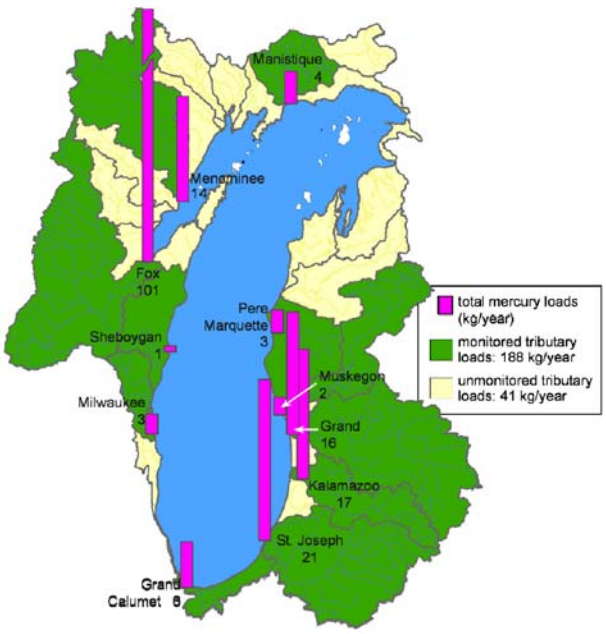


Figure 7-2. Total mercury loads (kg/year) to Lake Michigan from major monitored and unmonitored tributaries.
Source:USEPA Office of Research and Development

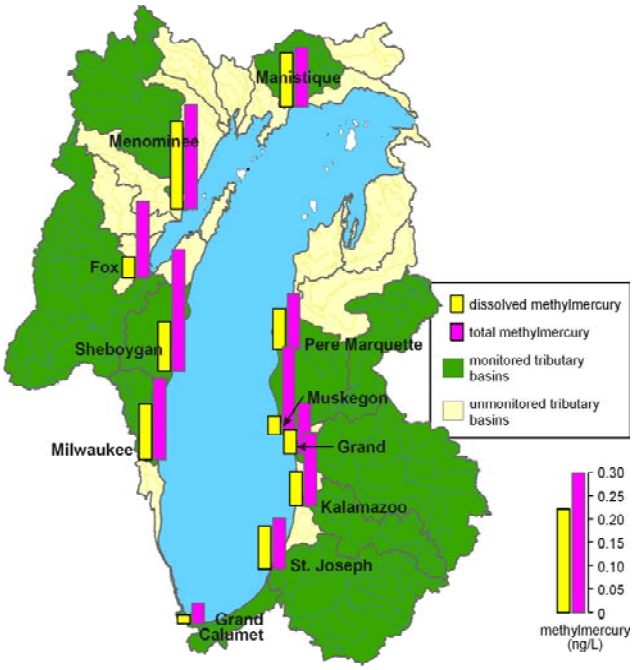


Figure 7-3. Dissolved and Total Average Methylmercury Concentrations in Monitored Tributaries.
Source:USEPA Office of Research and Development

Results of a dated sediment core provide a historical perspective of mercury in Lake Michigan. Results from a depositional basin indicate that concentrations of mercury peaked in the mid 1940s and have been declining since that time.

LMMB Major Findings: Mercury

- The current major source of mercury to the lake is from atmospheric deposition.
- Most Lake Michigan lake trout and coho salmon exceed the USEPA guidelines for unrestricted consumption.
- Modeling results suggest that a significant amount of the existing mercury settling out of water is being recycled back into the system.

Nutrients - Eutrophication

Eutrophication from excessive nutrient loads and nutrient concentrations has been under investigation and has received control strategies in the Great Lakes for the past 30 years.

LMMB Major Findings: Eutrophication

- Lake Michigan phosphorus loads and concentrations are low and below GLWQA and IJC targets.
- Tributaries are the major source of phosphorus to Lake Michigan.
- Highest concentrations can be observed in selected nearshore zones near tributary mouths and in Green Bay.
- There is no evidence of increasing loads or increasing concentrations in the open-water through 2002; forecasts indicate relatively stable phosphorus and chlorophyll-a concentrations into the future.

Pollutants and Pathways to Lake Michigan

While the LMMB study focused on four pollutants to develop a better understanding of pollutant fate and transport within the Lake Michigan ecosystem, many other pollutants are entering the ecosystem through a variety of pathways. The following discussion addresses recent investigations of four of these pathways:

- Atmospheric deposition,
- Nonpoint source runoff, including combined sewer overflows (CSO)
- Sediment, and
- Groundwater.

Atmospheric Deposition

The role of air pollution as an important contributor to water pollution has long been recognized and has been the subject of growing scientific study and concern in recent years. Over the past three decades, scientists have collected a large and convincing body of evidence showing that toxic chemicals released into the air can travel great distances before they are deposited on land or water. Most notably, PCBs and some persistent pollutants (including several pesticides that have not been used in significant amounts in the United States since the 1970s) have been widely distributed in the environment and are now part of the global atmospheric background. Section 112 of the Clean Air Act required congressional reports of the effect of air deposition on the "Great Waters" of the United States, including the Great Lakes where this pathway was documented.

Loadings of pesticides whose use has been canceled or restricted in the United States to Lake Michigan are primarily from atmospheric sources that is impossible to regulate or control. Although there are no current commercial sources of banned pesticides in the United States, loadings continue from use of remaining consumer stocks, evaporation from soils, resuspension of contaminated sediments, and atmospheric transport from other countries that continue to apply these substances. Further pesticide reductions can only be achieved through cleanup of contaminated sites, collection and disposal of existing stockpiles ("clean sweeps"), and use reduction in other countries. Between 1988 and 2001, USEPA Region 5 estimates that agricultural clean sweeps have removed 1.9 million pounds of pesticides from the Great Lakes basin.

While long-range atmospheric transport is an important pollutant source for Lake Michigan, recent studies also point to the influences of local sources, particularly from urban areas. For example, air sampling over Lake Michigan when the wind is blowing from the southwest shows contributions of PCBs, PAHs, and mercury from the Chicago area to the lake. The relative importance of each pollutant source to the overall loadings is variable depending on the season and local weather conditions.

Nonpoint Source Pollution

According to the USEPA National Water Quality Inventory Reports to Congress, states, tribes, and other jurisdictions consider siltation and the over enrichment of nutrients two of the three most significant causes of impairment in many of the streams throughout the Nation. Siltation alters aquatic habitat and suffocates fish eggs and affects other bottom dwelling organisms. Excessive nutrients have not only been linked to hypoxia in the Gulf of Mexico, but also to eutrophication and *Cladophora* blooms in many of the bays and beaches around Lake Michigan. Research in the 1960's and 70's linked *Cladophora* blooms to high phosphorus levels in the water, mainly as a result of agricultural runoff, detergents containing phosphorus, inadequate sewage treatment, and other human activities such as fertilizing lawns and poorly maintained septic systems (More information is available at *www.uwm.edu/Dept/GLWI/cladophora*). Due to tighter restrictions, phosphorus levels declined during the 1970's and *Cladophora* blooms were largely absent in the 1980's and 90's. Recently *Cladophora* blooms are again a common occurrence along the coast of Lake Michigan; however, the cause of these blooms is unknown.

USEPA identifies polluted runoff as the most important remaining uncontrolled source of water pollution and provides for a coordinated effort to reduce polluted runoff from a variety of sources. Previous technology-based controls, such as secondary treatment of sewage, effluent limitation guidelines for industrial sources, point sources and management practices for some nonpoint sources, have dramatically reduced water pollution and laid the foundation for further progress. However, nonpoint source loads continue to turn rivers and streams into pollutant pathways to the lake. Total maximum daily load (TMDL) studies are needed for impaired tributaries to identify the management measures needed to bring them back into compliance with water quality standards. Over the next several years, states will be developing many TMDLs for pollutants entering into water bodies from both point and nonpoint sources. TMDLs will provide data to help manage water quality on a watershed scale. See the watershed fact sheets in Chapter 12.

Major sources of nonpoint pollution include urban stormwater runoff, discharges from animal feeding operations, cropland runoff, and episodic combined sewer overflows. In addition, pollution can arrive via air from outside a watershed.

Urban nonpoint source stormwater is water from rain or snow that runs off city streets, parking lots, construction sites, and residential yards. It can carry sediment, oil, grease, toxicants, pesticides, pathogens, and other pollutants into nearby storm drains. Once this polluted runoff enters the storm sewer system, it is discharged, usually untreated, into local streams and waterways. It can contaminate drinking and recreational waters and remains a major source of beach closures.

In late 1999, USEPA promulgated rules to reduce stormwater runoff from construction sites between 1 and 5 acres and municipal storm sewer systems in urbanized areas serving populations of less than 100,000 through the issuance of permits. Generally, these controls were required to be in place by 2008 and build on the existing program to control stormwater runoff from municipalities with populations greater than 100,000 and 11 industrial categories, including construction disturbing over 5 acres. Under the expanded program, sediment discharges from approximately 97.5 percent of the acreage under development across the country will be controlled through permits. Many communities have passed ordinances to address the regulation with more being added every month.

The Lake Michigan basin has a high concentration of agricultural enterprises where animals are kept and raised in confined environments. Polluted runoff from animal feeding operations is a leading source of water pollution in some watersheds. Potential impacts include the absence or low levels of dissolved oxygen in surface water, harmful algae blooms, fish kills, and contamination of drinking water from nitrates and pathogens and beach closures.

For the vast majority of animal feeding operations (AFO), voluntary efforts will be the principal approach to assist owners and operators in developing and implementing site-specific management plans. Impacts from higher risk, concentrated animal feeding operations (CAFO), such as sites with the equivalent of 300 beef cows, will be addressed through National Pollutant Discharge Elimination System (NPDES) permits under the authority of the Clean Water Act. Wisconsin and Michigan developed state programs for control. About 5 percent of all animal feeding operations are expected to need permits.

The Lake Michigan Toolbox
Nitrogen Removal

A recent U.S. EPA report "Riparian Buffer Width, Vegetative Cover, and Nitrogen Removal Effectiveness: A Review of Current Science and Regulations", provides a synthesis of existing scientific literature on the effectiveness of riparian buffers to improve water quality through their inherent ability to process and remove excess anthropogenic nitrogen from surface and ground waters. The following URL will access a pdf of the report.

http://www.epa.gov/ada/download/reports/600R05118/600R05118.pdf

The Lake Michigan Toolbox
Catalog of Federal Funding Sources for Watershed Protection and Nonpoint Source Control

U.S. EPA has compiled a Catalog of Federal Funding Sources for watershed protection and nonpoint source control at http://cfpub.epa.gov/fedfund/. The web site is a searchable database of financial assistance sources (grants, loans, cost-sharing) available to fund a variety of watershed protection projects. Examples of funding sources include the U.S. EPA administered Section 319 Nonpoint Source grant program under the Clean Water Act and the Environmental Quality Incentives Program (EQIP) and the Conservation Reserve Easement Program (CREP) administered by the U.S. Department of Agriculture.

Phosphorus in the Lake Michigan Basin

Phosphorus has been shown to be the nutrient limiting production in Lake Michigan. To estimate where phosphorus originates in the watershed, results from

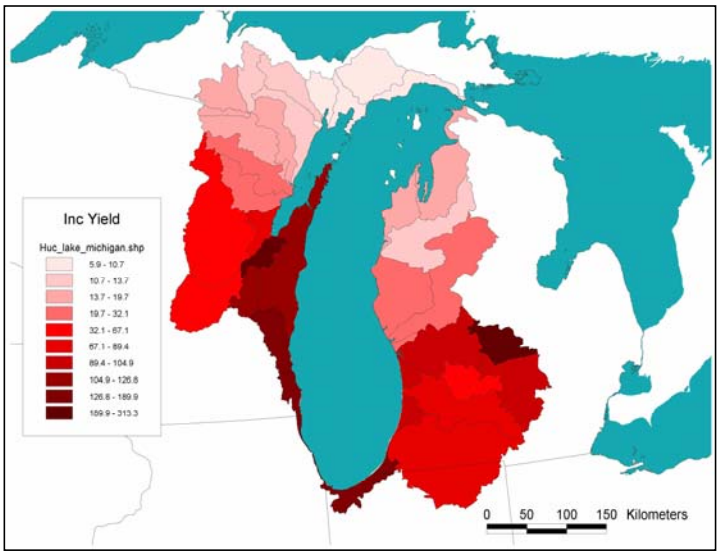


Figure 7-4. Phosphorus yields from Lake Michigan watersheds as estimated from the SPARROW model for conditions similar to 1992 (Alexander and others, 2008).

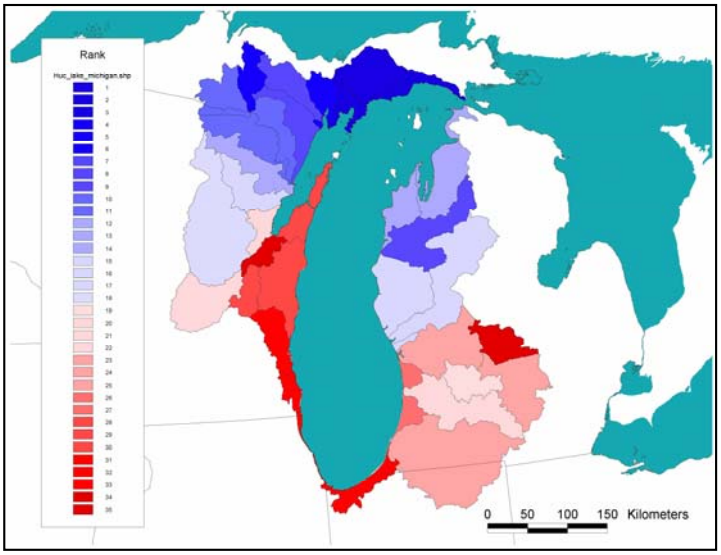


Figure 7-5. Ranking of phosphorus yields by watershed, based on the yields from Figure 7-4 (Alexander and others, 2008).

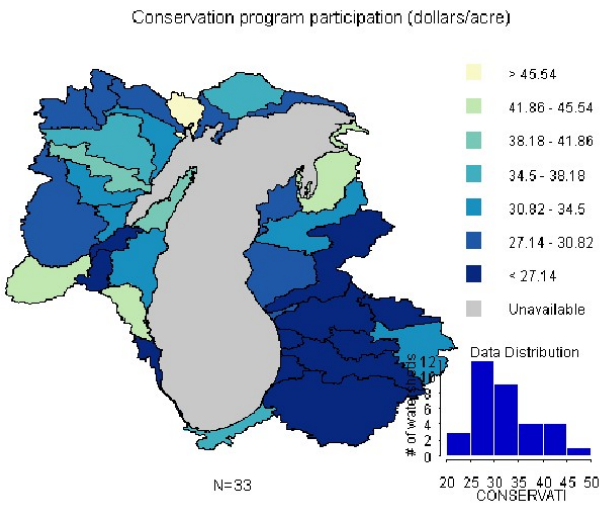


Figure 7-6. Conservation program participation (dollars/acre).
Source: USEPA

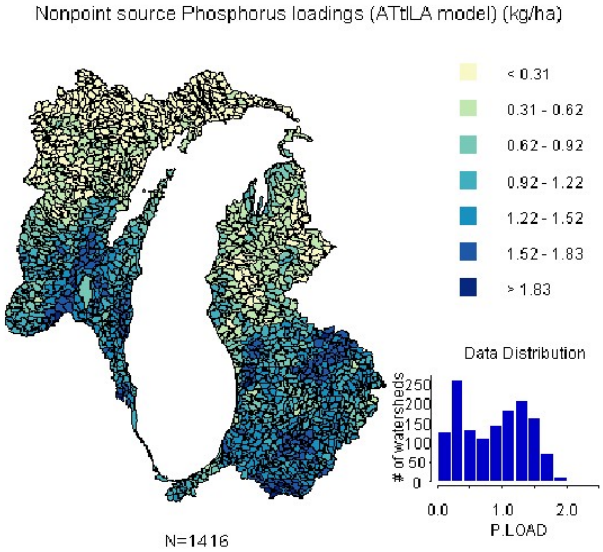


Figure 7-7. Nonpoint source phosphorus loadings.
Source: USEPA

the SPAtially Referenced Regressions on Watershed Attributes (SPARROW) model were examined for the Lake Michigan Basin (Figure 7-4). SPARROW is a hybrid statistical/deterministic model that relates water-quality monitoring data to watershed sources and characteristics. Results from SPARROW model demonstrate that the majority of the phosphorus load originates from the southern half of the drainage basin. The highest yields were estimated to be from West of the Fox River in Wisconsin, Northwest Indiana, and the Maple River watershed in Michigan. These areas have either intense agriculture or are highly populated. Relatively low yields were estimated from the forested areas in the Upper Peninsula of Michigan. This information can be used to rank the basins in terms of their relative yields to the lake (Figure 7-5).

The Lake Michigan Mass Balance project and the annual GLNPO open water sampling concentrate sampling for the open water of the lake for the targets set in the Great Lakes Water Quality Agreement.

While the open water targets were being met, there was a nearshore problem developing that resembled the problems of the 1960s-1980s, cladophora blooms. Research has linked these blooms to high phosphorus

levels in the water, mainly as a result of human activity such as fertilizing lawns, poorly maintained septic systems, inadequate sewage treatment, agriculture and urban runoff and detergents containing phosphorus. Due to past restrictions on some sources of nutrients, open water phosphorus levels declined during the 1980s and 90s, but recent research suggests that the invasion of zebra and quagga mussels in the Great Lakes are responsible for the increase in algae by increasing the availability of phosphorus for Cladophora and increasing water clarity as they feed on the plankton in the lake. Since we do not have management options to control the invasive mussel population, the nutrient control management options are again key to addressing the problem. Additional research on the dynamics of the nearshore is also needed.

What Action is Needed?

EPA is encouraging all states, territories and authorized tribes to accelerate their efforts and give priority to adopting numeric nutrient standards or numeric translators for narrative standards for all waters in states and territories that contribute nutrient loadings to our waterways. Incremental progress can be an effective way to accelerate progress. If a state needs to implement numeric nutrient criteria incrementally, EPA strongly recommends that states adopt numeric nutrient standards for their priority waters—i.e., waters at greatest risk of nutrient pollution (such as those identified through the EPA-USGS SPARROW modeling effort) or of greatest consequence (such as drinking water sources)—first. States may also choose to prioritize their actions for waters where sufficient information is available to move quickly to adopt numeric criteria in the near-term. The state's nutrient criteria plan should reflect the state's approach to setting standards for its waters, and include schedules for adopting those standards.

To be effective, nutrient criteria should address causal (both nitrogen and phosphorus) and response (chlorophyll-a and transparency) variables for all waters that contribute nutrient loadings to our waterways. EPA encourages the adoption of standards for all four parameters because of the interrelationships between these parameters and its experience showing that controlling both nitrogen and phosphorus is important to successfully combating nutrient pollution in all waters. As always, states, territories and authorized tribes have the flexibility to address nutrient pollution using a subset of or alternatives to these parameters if they are shown to be scientifically defensible and protective of designated uses.

With the establishment of numeric nutrient standards, state governments and local communities can set goals, establish controls, agree on risk management approaches, measure performance, demonstrate progress, and learn from each other. In a time of scarce resources and competing priorities, we cannot afford delayed or ineffective responses to this major source of environmental degradation.

Bans on the use of phosphorus-containing products are become more common. In 2003 Minnesota adopted a ban on application of phosphorus in lawn fertilizer and the amount of phosphorus applied via lawn fertilizer dropped from 292 tons to 151 tons. Both

Five-Year Review Report Completed, Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site, Kalamazoo, Michigan

On October 19, 2007, the Region 5 Superfund Division issued the first Five-Year Review Report for the Allied Paper Inc./Portage Creek/Kalamazoo River Superfund site, located in Kalamazoo, Michigan.

The site consists of six operable units (OUs). Record of Decisions (RODs) were issued for OU3 (February 1998), OU4 (September 2001), and OU2 (September 2006); the remaining OUs (OU1, OU5, and OU7) are in different stages in the Superfund cleanup process. The remedies selected for OU3, OU4, and OU2 include: consolidation and containment of polychlorinated biphenyl (PCB)-contaminated material; landfill cap over waste material; long-term monitoring; and deed restrictions limiting development of the property. The remedy has been constructed at OU3; is under construction at OU4; and has not yet been constructed at OU2.

The five-year review concluded that the remedy at OU3 is protective of human health and the environment in the short term. However, in order for the remedy to be protective in the long term, effective institutional controls need to be implemented and methane gas that has migrated off-site needs to be mitigated. The remedy at OU4 is not protective of human health and the environment because exposure pathways that could result in unacceptable risks are not controlled.

For more information, contact: Shari Kolak at 312-886-6151.

Draft Great Lakes Regional Collaboration Mercury Product Stewardship Phase-down

The Great Lakes Regional Collaboration (GLRC) held a sixty day (60) public comment period for a Draft Great Lakes Mercury Product Stewardship Strategy (http://www.glrc.us/initiatives/toxicsdrafthgphasedownstrategy.html) that ended at the end of October 2007. This Mercury in Products Phase-Down Strategy was developed in response to the Great GLRC Strategy to Restore and Protect the Great Lakes. The GLRC Strategy calls for the development of a basin-wide mercury product stewardship strategy designed to phase out the use of mercury and provide for mercury waste management. The GLRC document identifies full phase-outs of mercury-added products by 2015, as possible, as an interim milestone for toxics reduction.

Some states, tribes and cities in the Great Lakes basin have passed laws or have implemented programs to prevent pollution from mercury-containing products. This strategy seeks to build on those foundations to accomplish the 2015 phase-down goal. The strategy recommends a wide range of product-targeted policies for states to adopt, including sale bans and phase-outs, disposal regulations, public awareness and education programs, collection/end-of-life management for products, purchasing preferences, and labeling requirements. Some would require legislative action; others can be implemented by state, municipal or tribal agencies.

Wisconsin and Michigan have put limits on the large Confined Animal Feeding Operations which also contribute to the nutrient load. Indiana banned laundry detergents containing phosphorus in the 1970s and just passed a ban on eliminating phosphorus in dishwashing detergents for home use. The ban takes effect in July of 2010, giving industry time to distribute the new, reformulated product. In Michigan, bans on application of phosphorus containing fertilizers for residential use have been passed at both the county and local community level. Public education is also needed as many products are used without the soil tests to determine if they are needed since there is the recognition that some situations call for phosphorus like the establishment of a new lawn.

Areas of Concern: Legacy of Contamination and Community Stewardship

LaMP 2000 explained: In 1987 the Great Lakes Water Quality Agreement (GLWQA) between the US and Canada was expanded to address critical stressors affecting the basin's ecosystem. The intersections of major tributaries and the Lakes are areas where human activity by-products and collected river deposits concentrate. " The Parties recognize that there are areas in the boundary waters of the Great Lakes system where, due to human activity, one or more of the general or specific objectives of the Agreement are not being met. Pending virtual elimination of the persistent toxic substances in the Great Lakes system, the Parties, in cooperation with the State and Provincial Governments and the Commission, shall identify and work toward restoring and protecting beneficial uses in Areas of Concern or in open waters." (GLWQA)

For each AOC a stakeholder group was convened to work with federal and state agencies to develop remedial action plans that defined the problem and suggested remedial actions. This program has been very successful in capturing the energy and creativity of the communities. Unfortunately, agency funding and resources have been uneven and have never approached the scale needed for remediation of large-scale legacy sites. Federal authorities like Superfund, Resource Conservation and Recovery Act Corrective Action Program and the Clean Water Act have provided USEPA the tools to address some of the large-scale actions needed. The U.S. Army Corps of Engineers has been given specific program authority for AOCs.

Federal and State agencies and the AOC communities want to move ahead, remediate and restore impairments and delist their AOC. Matching authorities to specific impairment sources and the recovery time needed for the remediation actions to "take" in the environment are lengthy procedures. A number of new tools are now available:

- Delisting guidance finalized by Michigan and approved by USEPA GLNPO in January 2006.
- Delisting Principles and Guidelines- adopted by the U.S. Policy Committee in December 2001
- The Legacy Act of 2002- providing funding and new authorities for putting remediation partnerships together

Great Lakes Legacy Act

The Great Lakes Legacy Act (GLLA) is aimed at accelerating the pace of contaminated sediment

Great Lakes Basin Program for Soil Erosion and Sediment Control in Proposed Farm Bill

Congress included the Great Lakes Basin Program for Soil Erosion and Sediment Control as one of the conservation programs in the proposed 2007 Farm Bill. The legislation identifies the Basin Program as a means of achieving one of the top priorities of the Great Lakes Regional Collaboration Strategy to Restore and Protect the Great Lakes – reducing nonpoint source runoff from rural and urban areas.

The Great Lakes Basin Program for Soil Erosion and Sediment Control provides grants to local projects that help reduce soil erosion and sedimentation and otherwise control nonpoint source pollution on Great Lakes tributaries. By helping to keep excess sediment and land-based pollutants such as phosphorous and nitrogen out of the water, the program helps maintain clean sources of drinking water, protect fish and wildlife, and reduce the costs of dredging sediment from navigation channels and harbors. The program is administered by the Great Lakes Commission. Since 1991, the program has helped prevent more than 1 million tons of soil erosion and kept more than 5 million pounds of phosphorous out of Great Lakes tributaries.

Sediment Remediation New Grand Calumet River Great Lakes Legacy Act Project Agreement Signed

In April 26, 2007, a Project Agreement was signed by the U.S. EPA, the Indiana Department of Environmental Management (IDEM), and the remediation and develop the final design plans and specifications, general provisions, and special requirements necessary for sediment remediation at the West Branch Grand Calumet River (WBGCR) between Columbia and Hohman Avenues. This AOC represents one of the most heavily industrialized areas in the United States, contains steel mills and heavy manufacturing sites associated with the steel industry, petroleum-related land uses, packaging operations, chemical processing plants, and other industrial land uses. The WBGCR has received inputs of contaminants from various sources over the past century. In general, sediments in the river have elevated concentrations of heavy metals, PCBs, Semi-volatile organics (primarily PAHs), and pesticides (e.g., DDT and degradation products). This phase of the project is scheduled to be completed in early 2008 with the possibility that the project may eventually evolve into a remediation project. This will occur if the project successfully meets U.S. EPA's selection criteria identified in the Great Lakes Legacy Act Implementation Rule, and is agreed to by U.S. EPA, IDEM and IDNR.

remediation in Great Lakes' Areas of Concern (AOCs). The Act authorizes up to $50 million for projects that remediate contaminated sediments or lead to remediation. The goal of the U.S. Environmental Protection Agency's Great Lakes National Program Office is to identify and potentially remediate all eligible contaminated sediment sites within the 31 U.S. Areas of Concern.

As of July 2007, 3 remediation projects have been completed (Black Lagoon, Trenton, MI; Hog Island Inlet and Newton Creek, Superior, WI; and Ruddiman Creek and Pond, Muskegon, MI). Two remediation projects are underway (Ashtabula River, Ashtabula, OH and Tannery Bay St. Marys River, Sault Ste. Marie, MI), several assessment/feasibility/design projects, and follow up restoration projects are underway. The three completed projects have been highly successful from a technical point of view, attaining and/or exceeding the remediation goals established for the project.

The projects have also been highly successful in terms of attaining and/or exceeding the goals of the stakeholders, their communities and the municipal, county and state partners. The impacts of the remediation will be highlighted, as well as the roles and responsibilities from project submittal to completion, and the key factors that made the projects successful.

Under the GLLA a project is to be carried out in an AOC located wholly or partially in the United States, and the project:

1. monitors or evaluates contaminated sediment;
2. implements a plan to remediate contaminated sediment; or
3. prevents further or renewed contamination of sediment.

More information is available at http://www.epa.gov/glnpo/sediment/legacy/
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The LaMP Pollutant List

There are a number of pollutants that could be placed on the LaMP pollutant list. These were identified in LaMP 2004. The process for identifying LaMP pollutants, the 2004 pollutants list, potential pollutants to be added in 2006, and information on pollutant management activities completed since 2002 are presented in Appendix A.

Areas of Concern Overview

There is an increasingly strong focus on remediating the problems of areas of concern (AOCs). The ultimate goal is to ensure the effective clean-up of these contaminated areas and protect them by utilizing watershed stewardship activities as a means of ensuring their on-going protection.

The following matrix provides summary information for the Lake Michigan AOCs. It provides information regarding:

- AOC Name and Beneficial Use Impairments (BUIs)
- Primary Contaminants
- Geographic Area
- Stressors
- Programs
- Clean-Up Actions
- Key Activities Needed
- Challenges
- Next Steps

The Great Lakes Water Quality Agreement calls for Remedial Action Plans (RAPs) to restore and protect 14 beneficial uses in Areas of Concern. An impaired beneficial use means a change in the chemical, physical or biological integrity of the Great Lakes system sufficient to cause any of the impairments listed below (BUIs are listed in the AOC name column using the following numeration).

I. **Restrictions on fish and wildlife consumption** - When contaminant levels in fish or wildlife populations exceed current standards, objectives or guidelines, or public health advisories are in effect for human consumption of fish and wildlife.

II. **Tainting of fish and wildlife flavor** - When ambient water quality standards, objectives, or guidelines for the anthropogenic substance(s) known to cause tainting are being exceeded or survey results have identified tainting of fish and wildlife flavor.

III. **Degraded fish and wildlife populations** - When fish or wildlife management programs have identified degraded fish or wildlife populations. In addition, this use will be considered impaired when relevant, field-validated, fish and wildlife bioassays with appropriate quality assurance/quality controls confirm significant toxicity from water column or sediment contaminants.

Michigan Begins to Apply AOC Delisting Document

The Michigan Department of Environmental Quality's Water Bureau recently published its Guidance for Delisting Michigan's Great Lakes Areas of Concern. The Guidance includes specific, measurable criteria for restoration and removal of Beneficial Use Impairments identified in Annex 2 of the 1987 Amendments to the Great Lakes Water Quality Agreement. The delisting criteria have been applied in most of Michigan's Lake Michigan AOCs, including the removal of the Degradation of Benthos Beneficial Use Impairment in Manistique River. This presentation will provide an overview of Michigan's delisting criteria and focus on application of specific criteria, using Manistique River, Muskegon Lake, White Lake, and Kalamazoo River as case studies for Michigan's Areas of Concern.

IV. **Fish tumors or other deformities** - When the incidence rates of fish tumors or other deformities exceed rates at unimpacted control sites or when survey data confirm the presence of neoplastic or preneoplastic liver tumors in bullheads or suckers.

V. **Bird or animal deformities or reproductive problems** - When wildlife survey data confirm the presence of deformities (e.g. cross-bill syndrome) or other reproductive problems (e.g. egg-shell thinning) in sentinel wildlife species.

VI. **Degradation of benthos** - When the benthic macroinvertebrate community structure significantly diverges from unimpacted control sites of comparable physical and chemical characteristics. In addition, this use will be considered impaired when toxicity (as defined by relevant, field-validated bioassays with appropriate quality assurance/quality controls) of sediment-associated contaminants at a site is significantly higher than controls.

VII. **Restrictions on dredging activities** - When contaminants in sediments exceed standards, criteria, or guidelines such that there are restrictions on dredging or disposal activities.

VIII. **Eutrophication or undesirable algae** - When there are persistent water quality problems (e.g. dissolved oxygen depletion of bottom waters, nuisance algal blooms or accumulation, decreased water clarity, etc.) attributed to cultural eutrophication.

IX. **Restrictions on drinking water consumption or taste and odor problems** - When treated drinking water supplies are impacted to the extent that: 1) densities of disease- causing organisms or concentrations of hazardous or toxic chemi-

cals or radioactive substances exceed human health standards, objectives or guidelines; 2) taste and odor problems are present; or 3) treatment needed to make raw water suitable for drinking is beyond the standard treatment used in comparable portions of the Great Lakes which are not degraded (i.e. settling, coagulation, disinfection).

X. Beach closings - When waters, which are commonly used for total-body contact or partial-body contact recreation, exceed standards, objectives, or guidelines for such use.

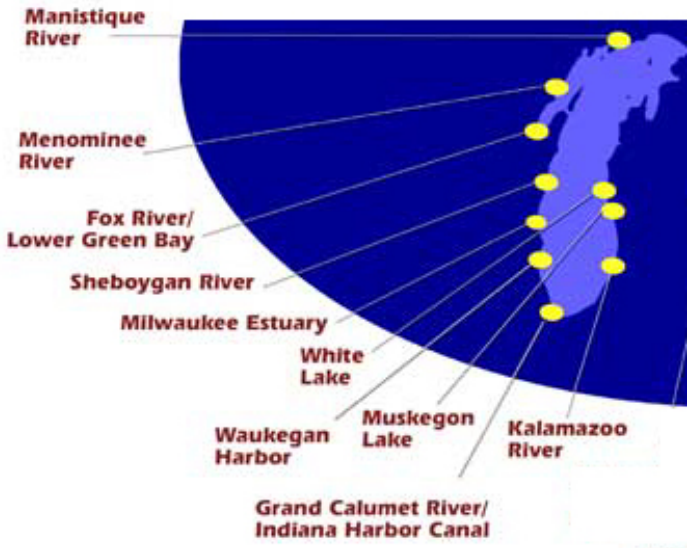
XI. Degradation of aesthetics - When any substance in water produces a persistent objectionable deposit, unnatural color or turbidity, or unnatural odor (e.g. oil slick, surface scum).

XII. Added costs to agriculture and industry - When there are additional costs required to treat the water prior to use for agricultural purposes (i.e. including, but not limited to, livestock watering, irrigation and crop-spraying) or industrial purposes (i.e. intended for commercial or industrial applications and noncontact food processing).

XIII. Degradation of phytoplankton and zooplankton - When phytoplankton or zooplankton community structure significantly diverges from unimpacted control sites of comparable physical and chemical characteristics. In addition, this use will be considered impaired when relevant, field-validated, phytoplankton or zooplankton bioassays (e.g. Ceriodaphnia; algal fractionation bioassays) with appropriate quality assurance/quality controls confirm toxicity in ambient waters.

XIV. Loss of fish and wildlife habitat - When fish or wildlife management goals have not been met as a result of loss of fish or wildlife habitat due to a perturbation in the physical, chemical or biological integrity of the Boundary Waters, including wetlands.

Lake Michigan Areas of Concern



AOC Name, Location and BUIs	Stressors and Primary Contaminants	Programs	Clean-Up Actions	Delisting Targets Set?	Key Activity Needed	Challenges	Next Steps
Grand Calumet River **Indiana** Grand Calumet River: Lagoon, East Branch and West Branch Indiana Harbor and Ship Canal, The Lake George Branch of the Canal, Wolf Lake, George Lake and Nearshore Lake Michigan. Listed BUIs I, II, III, IV, V, VI, VII, VIII, IX, X, XI, XII, XIII, XIV Delisted BUIs	• PCB and mercury Contaminated Sediments • Pathogens from Combined Sewer Overflows • Contaminated groundwater • Contaminated land sites • Habitat Fragmentation • Fire Suppression • Aquatic nuisance species • PAHs • Biochemical oxygen demand • Suspended solids • Oil and grease • PCB • Mercury • Metals	• Superfund • RCRA • Clean Water Act • WRDA • Navigational Dredging • Natural Resource Trustee's Damage Assessment • Great Lakes Legacy Act	• West Branch Remediation – a sediment dredging and habitat restoration demonstration project at the East Chicago Sanitary District Canal has been designed by the USACE and ECSD • U. S. Steel Gary Works dredging of 5 river miles on the East Branch complete including 824,00 cubic yards of sediment removed from the river and placed in the Corrective Action Management Unit (CAMU). • GSD Sediment Remediation-selected remedial option is currently being considered by EPA • Navigational dredging • U.S. Lead - 19,000 cubic yards of sediment have been remediated • A total of 700,000 cubic yards of sediment have been remediated • IDEM and EPA are currently working on the amendment to currently existing federal consent decrees to address CSO long term control plan issues.	• Delisitng targets for all 14 listed BUIs will be in place by December 31, 2008.	• Sediment remediation • CSO Long Term Control Plans • Issue NPDES Permits • BUI Indicator Monitoring • West Branch assessment completed in 2002 • Remedial Alternatives Development Report completed in 2006 • Coordination with RAP program for AOC delisting purposes	• Public concern regarding location of contaminated material disposal • Local funding and match for federal projects • Legal concerns • Permitting • Monitoring resources • The draft Water Quality Component of Stage Two includes some provisions being implemented through indirect methods; direct resources for implementation have been limited	• EPA GLNPO - IDEM - IDNR are working in partnership with the Great Lakes Legacy Act to remediate the West Branch of the Grand Calumet River. • Dredging at U. S. Steel complete • NRDA-Consent decree has been entered and restoration planning is underway • ACOE- WRDA Diagnostic Feasibility Study • GSD-Site Characterization • Monitor BUI Indicators • CDF construction is currently underway • The RAP process has developed and obtained funds for a Toxic Pollution Prevention (TPP) Program

AOC Name, Location and BUIs	Stressors and Primary Contaminants	Programs	Clean-Up Actions	Delisting Targets Set?	Key Activity Needed	Challenges	Next Steps
Kalamazoo River **Michigan** I, III, V, VI, VII, X, XI, XIV From Morrow Dam, which forms Morrow Pond and extends about 80 miles downstream to Lake Michigan. Also includes about three miles of Portage Creek.	• PCBs in Sediments • Failing dams forming onstream impoundments that house PCB contaminated sediments • PCB/Sediment source areas such as riverside former mill properties, disposal areas, and landfills, and river banks, and floodplains. • Nonpoint pollution • Phosphorus • Sediments • Nitrates • Salt • Mercury • Dioxin (2008 draft IA) • E.coli • Antiquated land use policies/ ordinances	• Superfund • Clean Water Act • Brownfields • Natural Resource Trustee's Damage Assessment	• Superfund removal of 150,000 cubic yards of PCB-contaminated sediments from Bryant Mill Pond • Contaminated material removal from former Georgia Pacific and Hawhthorne Mill properties • Post Record of Decision landfill closure occurring at Willow Blvd./A-Site and 12th Street • Contained material removal and offsite disposal year 1 of 2 completed in river, bank, and floodplain near Plainwell (Plainwell Dam removal integrated into the cleanup effort) • Additional progress at other Superfund Operable Units • Sub-basin Watershed Management/nonpoint pollution projects Erosion control programs, and stormwater management projects • A phosphorus TMDL for Lake Allegan and the river upstream has been established; measures are being implemented to reduce phosphorus pollution from point and nonpoint source partners	• Yes; working on finalizing targets for Loss of Fish and Wildlife Habitat and Degradatio n of Populations	• Dredging/ Excavation/Safe Disposal • Superfund site cleanup decision action • Stream buffers/river corridor habitat connections and preservation • Dam removal • Coordination between Superfund, NRDA, stormwater, TMDL, and RAP programs necessary for AOC delisting purposes	• Local funding match for federal projects • Sustainable funding for public advisory councils and other watershed project implementers • Decisions and actions on the remediation of this Superfund Site have recently accelerated and this momentum should be fostered with community participation and departmental collaboration from federal, state, and local program partners	• Continue NRDA tracking • Continue remedial investigation/ remedial action at operable units and newly defined river reaches in Operable Unit 5 • RAP to be revised as Community Action Plan n 2008 • Kalamazoo River/Lake Allegan TMDL (Total Maximum Daily Load) continues • Fish and Wildlife Habitat Restoration tasks to be identified and pursued • Work to Remove Beach Closing BUI and Aesthetics BUI • Formalize PAC operations as a watershed umbrella organization • Formalize a draft watershed partnership agreement • Write watershed nonpoint source plan

Lake Michigan Areas of Concern Summary Matrix
LaMP 2008 Update

For more information, see http://www.epa.gov/glnpo/aoc

AOC Name, Location and BUIs	Stressors and Primary Contaminants	Programs Programs	Clean-Up Actions	Delisting Targets Set?	Key Activity Needed	Challenges	Next Steps
Lower Fox River/ Southern Green Bay **Wisconsin** The lower 40 miles of the Fox River and Green Bay I, III, V, VI, VII, VIII, IX, X, XI, XIII	• PCBs • Phosphorus • Suspended solids • Mercury • Urban and rural runoff • Sediments • Aquatic exotic species • Wetland loss • Habitat alteration	• Clean Water Act – Integrated TMDL for the Lower Fox • Superfund • Natural Resource Trustee's Damage Assessment	• Watershed NPS abatement • Remedial investigation completed remedial action nearly ongoing. Dredging and PCB removal (Deposit in 11,000 cubic yards of sediment removed,, Deposit 56/57: 80,000 cubic yards of sediment removed OU1 335,000 cubic yards of sediment removed, and Phase I, 132,000 cubic yards of sediment removed) • Dissolved oxygen wasteload • Deposit N, 56, 57 • Cumulative sediments remediated from 1998-2007 – 558,000 cubic yards • Consent Decree for Phase I Fox River clean-up announced 4/12/06, Unilateral Administrative Order issued November 2007 for remainder of river contamination (from OU2 to OU5)	• No, will be started in 2008	• Dredging • Pollution Prevention • Stream buffers • Habitat protection and restoration • Coordination with RAP program for AOC delisting purposes • Coordination with integrated TMDL	• Rapid land development • Contaminated material disposal • Seeing through completion of cleanup for OUs 2-5	• Implement 4/12//06 Consent Decree for detailed engineering for the final cleanup plan. • Compliance with the Unilateral Administrative Order issued November 13, 2007 • Remediation (using dredging/disposal, capping and sand covers) I of an additional 7.5 million cubic yards of sediment. • Final cleanup expected to be complete approximately 2020. River monitoring will continue indefinitely. • Implement integrated TMDL
Manistique River **Michigan** The last 1.7 miles of the river to the mouth of the harbor at Lake Michigan I, VII, X, XIV BUI VI delisted	• PCBs • Combined sewer overflow • PCB-contaminated sediments • Superfund	• Superfund • USACE	• Dredging of contaminated sediments completed in 2000 (190,000 cubic yards) • Manistique Wastewater Treatment Plant made improvements to its system toward elimination of CSOs • Degradation of benthic community beneficial use impairment delisted.	• Yes, all delisting targets were set in 2006	• Sampling and monitoring follow-up to confirm downward trends of contamination • Coordination with RAP program for AOC delisting purposes	• Navigational dredging • Fish consumption advisories • CSO to be closed by 2020	• Sampling and monitoring continuing as part of delisting process

AOC Name, Location and BUIs	**Stressors and Primary Contaminants**	Programs	Clean-Up Actions	Delisting Targets Set?	Key Activity Needed	Challenges	Next Step
Menominee River **Michigan/ Wisconsin** Lower 4.8 km of river to the mouth and 5 km north and south of the mouth along the Green Bay shore I, III, VI, VII, X, XIV	• Lloyd/Flanders Paint Sludge Site-high level of lead and other heavy metals coated sediments where deposited • Arsenic • Mercury • PCBs • PAHs • Oil and grease • Pathogens • Sediments • Coastal wetlands habitat loss • Nonpoint pollution • Historic shoreline developments to support harbor activities	• MDNR-Administrative Order • RCRA Corrective Action • Superfund • Menominee Watershed Intiaative	• Paint sludge cleanup completed in 1995 (10 million pounds of hazardous waste from Bay and 20 million pounds of contaminated sediments. • Development of cleanup plans for the Ansul site and river.	• In progress.	• Arsenic source control • Dredging of arsenic and coal tar contaminated sediments • Protect riparian and coastal habitat • Manufactured Gas Plant PAH site remediation and dredging.	• Funding for dredging the Menekaunee Harbor. • Funding needed for monitoring for BUI evaluation and delisting targets.	• Ansul site barrier wall installation. • Complete Arsenic dredging • Manufactured Gas Plant site remediation and dredging for coal tar (PAHs). • Identify sources for fish consumption advisories (mercury, PCBs, dioxin) to ensure that sources are controlled
Milwaukee Estuary **Wisconsin** The lower 5 km of the Milwaukee River ; the lower 4.8 km of the Menominee River; the lower 4 km of the Kinnickinnic River; the inner and outer Harbor and the nearshore waters I, III, IV, VI, VII, VIII, X, XI, XIII, XIV	• Phosphorus • Pathogens • PCBs • Metals • PAHs • Urban and rural runoff • Wastewater discharges • Sediments • Habitat loss • Dams	• Clean Water Act • Clean Air Act • Superfund • Brownfields • Navigational dredging	• Milwaukee Estuary Fish spawning habitat improvement project • Kinnickinnic River Remediation planned for 2008-09	• In progress	• Dredging • Nonpoint source pollution control • Stream buffers • Pathogen source research • Coordination with RAP program for AOC delisting purposes	• High urban density and rapid development • Historic developed sites which could be restored to improve floodplain functions and wetland function	• Estabrook Impoundment remediation needed (assessment in progress) • Watershed analysis to assess water quality impacts and options for restoration (funding needed)

Lake Michigan Areas of Concern Summary Matrix
LaMP 2008 Update

For more information, see http://www.epa.gov/glnpo/aoc

AOC Name, Location and BUIs	Stressors and Primary Contaminants	Programs Programs	Clean-Up Actions	Delisting Targets Set?	Key Activity Needed	Challenges	Next Steps
Muskegon Lake **Michigan** The entire 4149 acre lake and several tributaries within the immediate watershed. I, V, VI, VII, VIII, IX, XIV	• PCBs • Mercury • Unstable hydrologic flow • Contaminated Sediments • Nonpoint pollution • Coastal wetlands and habitat loss, isolation and fragmentation	• Shoreline Brownfield Redevelopment Authority • Navigational dredging • Great Lakes Legacy Act and Clean Michigan Initiative • Superfund • Non-point Source • USACE • US Fish and Wildlife Service - Coastal Program	• Wastewater treatment upgraded • Some tributary remedial actions underway • Removal of about 90,000 cubic yards of contaminated sediment in Ruddiman Creek	• Yes targets are set and approved by the Muskegon Lake Watershed Partnership and MDEQ for six (6) of the nine(9) BUIs: 1) Fish consumption advisories; 2) Beach Closings; 3) Degraded Benthos; 4) Restrictions on Dredging; 5) Degradation of Aesthetics; 6) Eutrophication/ Undesireable Algae; ; Working on finalizing targets for Loss of Fish and Wildlife Habitat, Degradation of Populations, and Restrictions on Drinking Water	• Contaminated Sediment Remediation • Stream buffers for improved habitat and water quality • More assessment for progress on attaining BUI targets • TMDL Assessments for Muskegon Lake; Ruddiman Creek; Ryerson Creek; Bear Lake • Habitat restoration along Muskegon Lake's south shoreline and adjacent mouths of tributaries and lower river mouth • Coordination with RAP program for AOC delisting purposes	• PCB disposal • Local funding match for federal projects • Base support for local coordination of AOC/PAC process	• Remediation of brownfields and sediments • Sediment remediation in Muskegon Lake at the Division Street Outfall. • Fish and Wildlife Habitat Restoration
Sheboygan River **Wisconsin** The lower Sheboygan River downstream from the Sheboygan Falls Dam, including the entire harbor and nearshore waters I, III, V, VI, VII, VIII, XIII	• Suspended Solids • PCBs • PAHs • Heavy Metals • Pathogens • Phosphorus • Nonpoint source pollution • Habitat restoration on streambanks and wetland areas	• Superfund • RCRA Corrective Action • Clean Water Act #319	• The former Tecumseh plant site PCB hot spot removal and cut-off trench installed along the Sheboygan River removing any preferential pathways for contaminants to move to the river from the site. • Removal of 20,700 cubic yards of PCB-contaminated sediments from Sheboygan Falls downstream to the Waelderhaus Dam – 4.5 miles of river. • Brownfield remediation on the C. Reiss Coal site.	• In progress.	• Completion of PCB remediation • Completion of PAH remediation at Camp Marina coal gasification site • Control buffers • Habitat protection • NPS controls for urban and rural pollution • Development of Delisting Targets for AOC.	• Funding needed for monitoring for BUI evaluation and delisting targets. •	• Conduct sediment recharacterization for the Middle River, Lower River and Inner Harbor reaches. • Complete dredging. • Dredge PAH contaminated sediment at the manufactured Gas Plant. • Conduct post-remedial monitoring at the site and in the Upper River section.

Lake Michigan Areas of Concern Summary Matrix
LaMP 2008 Update

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AOC Name, Location and BUIs	Stressors and Primary Contaminants	Programs	Clean-Up Actions	Delisting Targets Set?	Key Activity Needed	Challenges	Next Steps
Waukegan Harbor **Illinois** 1.2 square kilometers of industrial, commercial, municipal and open lands. VI, VII, X, XIII, XIV	• PCB contaminated sediments	• Superfund • Clean Water Act #319	• Approximately 1 million pounds of PCBs dredged from the harbor • Soil removal activities completed at Waukegan Manufactured Gas and Coke site in 2005; extraction and treatment of contaminated groundwater to continue at the site for several years • Removal and disposal of large amounts of acids, bases, paints, solvents, hydraulic oil, machining oil, compressed gases, metals, sludge and PCB-containing transformer fluid from the Waukegan lakefront site	• In progress	• Dredging • Brownfield development • Habitat restoration • Coordination with RAP program for AOC delisting purposes	• Dredging for navigation and contaminated sediment removal • Contaminated sediment disposal • Funding to fulfill local match for dredging and remediation projects	• Pursuit of a dredging plan for the removal of PCB contaminated sediments from Waukegan Harbor • Final dredging and disposal of Waukegan Harbor sediments • Outboard Marine Corporation building, soil and groundwater remediation • Implementation of best management practices to reduce nonpoint source pollution and improve water quality in the Waukegan River watershed, as per the watershed plan
White Lake **Michigan** Includes White Lake and a one-quarter mile wide zone around the lake. I, III, VI, VII, VIII, IX, XI, XIV	• Heavy metals • Stormwater nonpoint pollution • Arsenic • Chromium • Sediments • Industrial contamination • Groundwater contamination	• Superfund • RCRA	• Dredging in ATannery Bay@ (2002) – 73,000 cubic yards of waste (hides, chromium, and arsenic) • Cleanup of Occidental Chemical site in 2002 • Potential sources of groundwater contamination to White Lake and its tributaries have been identified and remediation efforts are underway • Some eutrophication has been alleviated by improvements to the sewage collection and treatment systems • Contaminated groundwater venting to the lake is being intercepted by purge wells and treated prior to	• Yes; Targets are pending MDEQ approval	• Assessment and further study of contaminated sites • Coordination with RAP program for AOC delisting purposes	• Monitoring achievement of delisting targets	• Further study of the extent of contamination from the Whitehall Leather Company is needed, in addition to possible remediation funds. • Assessment is needed of sediments at discharge points for other contaminated sites • Fish and Wildlife Habitat Preservation