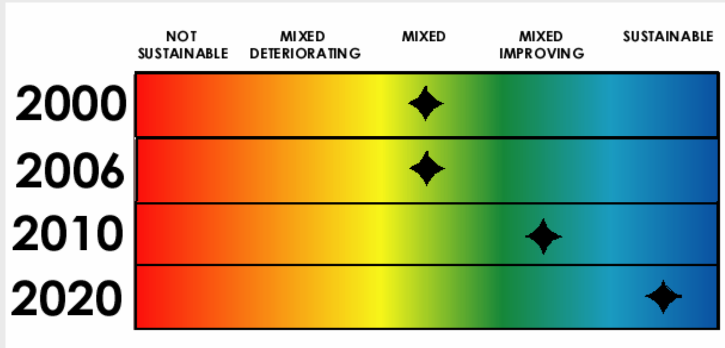
Subgoal 7
Are sediments, air, land, and water sources or pathways of contamination that affect the integrity of the ecosystem?

Status

Sediments, air, land, and water continue to be sources or pathways of contamination that affect the integrity of the Lake Michigan ecosystem. While regulatory and remediation programs reduce pollutant sources, ongoing releases and the region's legacy of contamination continue to serve as sources of pollutants. As a result, the status of this goal is mixed. There has been significant activity that will assist in changing the status to mixed/improving over the next decade. In particular, the findings of the Lake Michigan Mass Balance Study will allow decision-makers to better understand pollution pathways and adopt policies to address pollutant sources. Please also see Chapters 1 and 11.

Lake Michigan Target Dates for Sustainability



Indicators (State of the Lakes Indicators by Number)

- 106 - Nutrient Management Plans
- 111 - Phosphorus Concentrations and Loadings
- 114 - Contaminants in Young-of-the-Year Spottail Shiners
- 115 - Contaminants in Colonial Nesting Waterbirds
- 117 - Atmospheric Deposition of Toxic Chemicals
- 118 - Toxic Chemical Concentrations in Offshore Waters
- 119 - Concentrations of Contaminants in Sediment Cores
- 121 - Contaminants in Whole Fish
- 124 - External Anomaly Prevalence Index for Nearhore Fish
- 4177 - Biologic Markers of Human Exposure to Persistent Chemicals
- 4201 - Contaminants in Sport Fish
- 4202 - Air Quality
- 4506 - Contaminants in Snapping Turtle Eggs
- 4860 - Phosphorus and Nitrogen Levels (Coastal Wetlands)
- 8135 - Contaminants Affecting Productivity of Bald Eagles
- 8147 - Contaminants Affecting the American Otter
- 4175 - Drinking Water Quality
- 9000 - Acid Rain

Challenges

- Regional growth leading to demands for new power generating plants and emissions
- Research on phosphorus sources and near shore effects
- Research on conversion of mercury to methyl mercury
- Additional monitoring and data needed on emerging contaminants
- Clean-up and delisting of 10 Areas of Concern

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 control and pollution control measures
- 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 will be updated for Legacy Act funding or delisting opportunities
- Investigate nutrient contributions from the agricultural sector and non point sources during wet weather. Determine if nutrient levels are linked to *Cladophora* blooms
- Hold meetings to discuss Lake Michigan Mass Balance models and implications for Impaired Waters Strategy
- Develop Impaired Waters Strategy through basinwide meeting

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.
- 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

Great Lakes Regional Collaboration Action Items

Nonpoint Source Pollution

Non point sources of pollution contribute significantly to problems in the Areas of Concern, as well as to other locations in the Great Lakes, including the open waters. Actions to address these problems include:

- wetland restoration;
- restoration of buffer strips;
- improvement of cropland soil management;
- implementation of comprehensive nutrient and manure management plans for livestock operations; and
- improvements to the hydrology in watersheds.

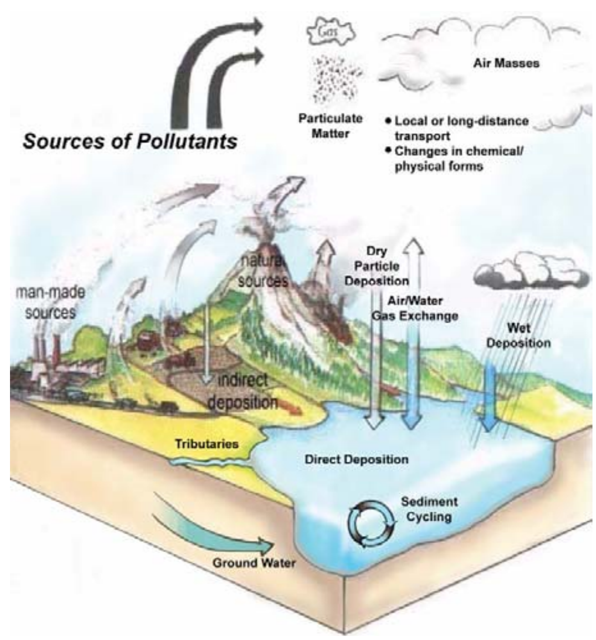


Figure 7-1 Pollutants enter and leave Lake Michigan through several pathways
Source: www.epa.gov/owow/oceans/airdep
Augmented by Joseph F. Abboreno, LaMP 2002

All graphics, with the exceptions of Figures 7-1 and 7-10, were created by USEPA/Office of Research and Development based on information from the publications referenced in the text of this chapter.

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.

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 (Figure 7-2). 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.

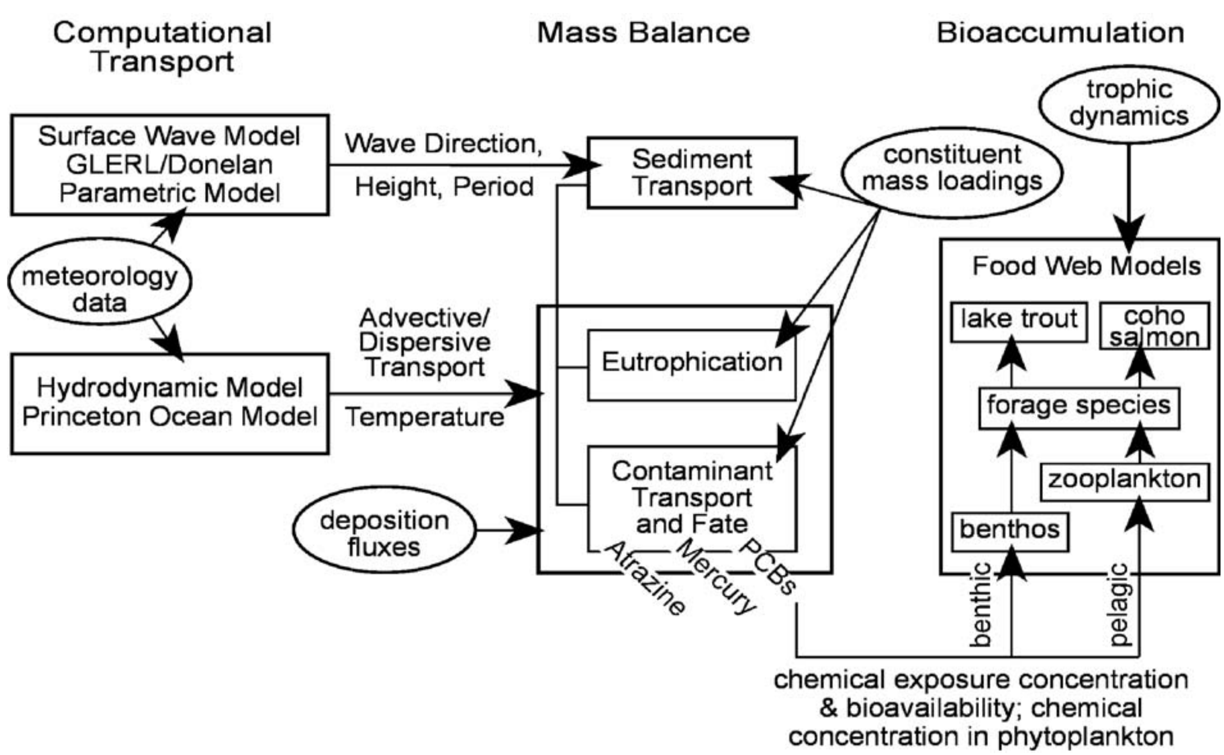


Figure 7-2. Lake Michigan Mass Balance Modeling Framework

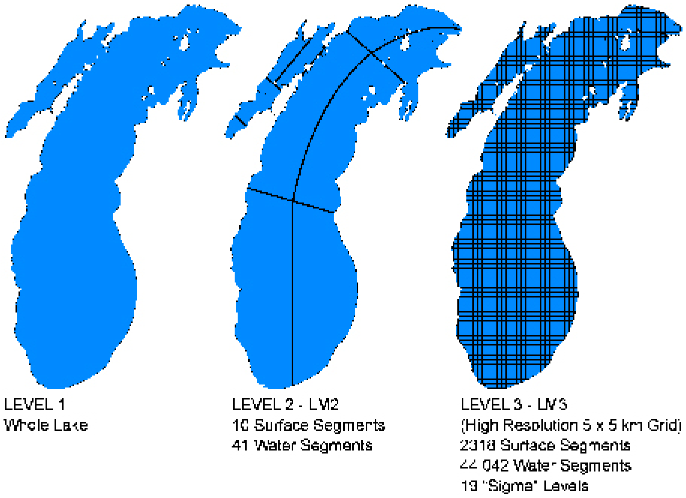


Figure 7-3. Lake Michigan Mass Balance project water

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.

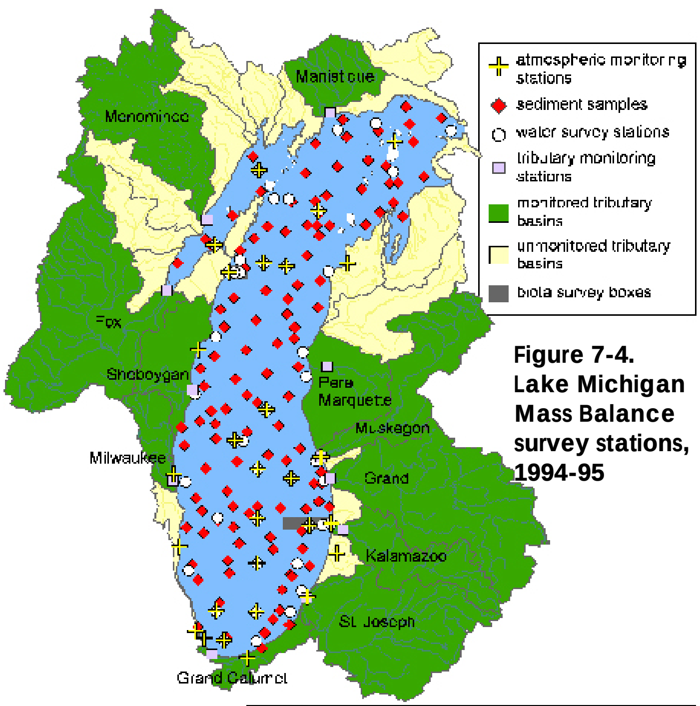


Figure 7-4. Lake Michigan Mass Balance survey stations, 1994-95

The modeling construct was applied to the study contaminants, where appropriate, and used three different spatial resolutions (Figure 7-3). 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.

Sample Design and Sample Collection

To characterize Lake Michigan, over 200 locations (stations) were sampled during the course of the project (Figure 7-4). Samples were collected for air, water, sediment, tributary mouths, and biota. Over 35,000 samples were collected for the Lake Michigan Mass Balance during the 1994 and 1995 sampling seasons. The study produced approximately 1,000,000 analytical data points.

The field sample collection methods and the laboratory methods used in analyses are documented in the Lake Michigan Mass Balance Methods Compendium (USEPA 1997b; 1999c; 1997d) and elsewhere (www.epa.gov/glnpo/lmmb/methods/index.html).

In addition to the atmospheric, sediment, and water survey stations, the study intensively collected biota at the Saugatuck and Sturgeon Bay collections zones. The eleven (11) major monitored tributary mouths sampled were the Fox, Sheboygan, Milwaukee, Grand Calumet, St. Joseph, Kalamazoo, Grand, Muskegon, Pere Marquette, Manistique, and Menominee Rivers. The above monitored tributaries had direct measurements

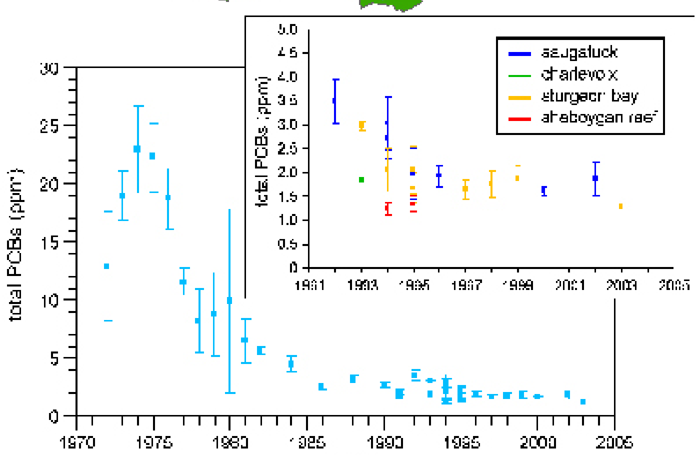


Figure 7-5. Total PCB concentrations in Lake Michigan Lake Trout

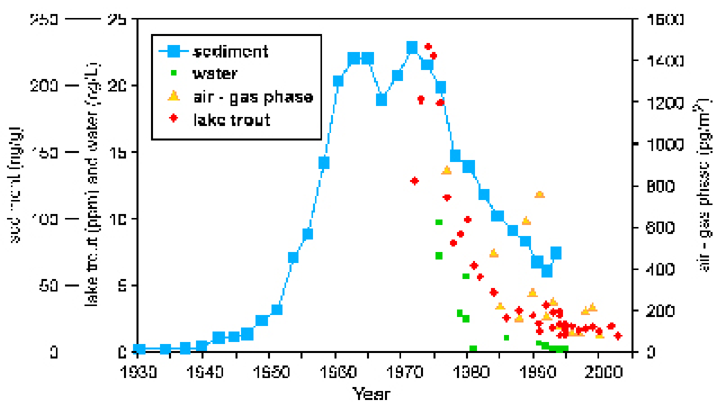


Figure 7-6. Trends of Total PCBs in Various Lake Michigan Media.

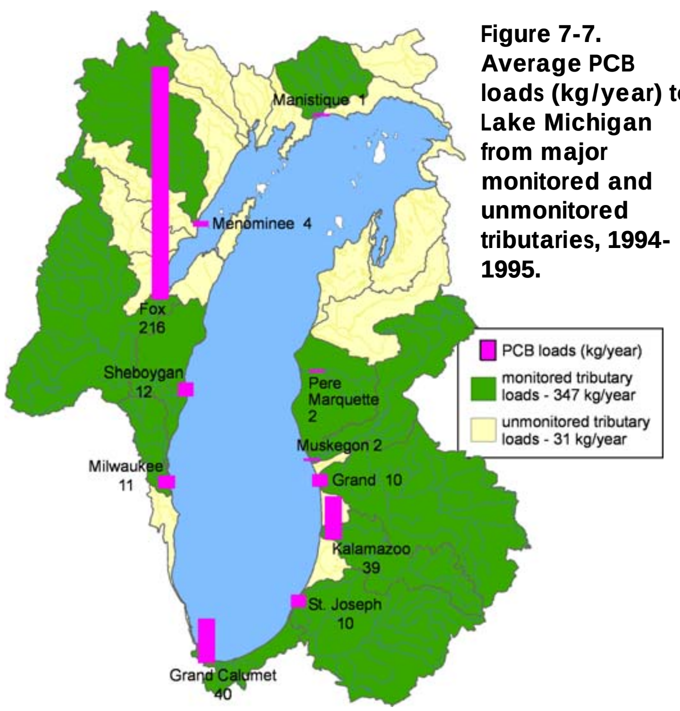


Figure 7-7. Average PCB loads (kg/year) to Lake Michigan from major monitored and unmonitored tributaries, 1994-1995.

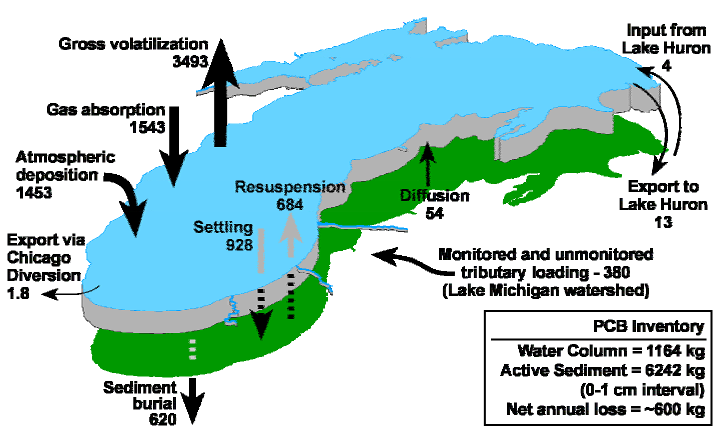


Figure 7-8. Total PCB Mass Balance (kg/yr) for 1994-1995

made over a time series at river mouths and had constituent loadings calculated directly from the data. Loading information for the unmonitored tributaries used watersheds of like characteristics and loadings were estimated through extrapolation (Hall and Robertson 1998).

Lake Michigan PCBs

Polychlorinated biphenyls (PCBs) are a class of manmade, chlorinated, organic chemicals that include 209 congers, 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 (Figure 7-5). 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 (Figure 7-6). 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).

Figure 7-7 shows a summary of PCB loads from tributaries in 1994-1995 Hall and Robertson 1998; Hall et al. 2001). Total tributary loads of PCBs are approximately 400 kg/yr for the study period. The largest loads are from the Fox River, followed by the Grand Calumet and Kalamazoo Rivers.

The relative importance of sources and losses of PCBs in the entire system is provided in Figure 7-8 and is the result from the LM2 PCB model (Ambrose et al 1983;

1988; 1993; Thomann and Connolly 1984; Wanninnkhoff 1992; USEPA 1993; Hornbuckle et al 1995; Hydroqual 1996; Beletsky et al 1997; Franz et al 1998; Schwab and Beletsky 1998; Richardson et al 1999; Bamford et al. 2000; 2002; Green et al. 2000; Miller et al 2001; Velleux et al 2001; USEPA 2004; Endicott 2005; Endicott et al. 2005; Pauer et al 2006). The largest source of PCBs to Lake Michigan is gas phase absorption from the atmosphere to the surface of the lake water. The next largest source is from atmospheric deposition (wet and dry deposition) followed by tributary loading. The largest loss of PCB from the system is from gross volatilization to the atmosphere. Permanent burial of PCBs in sediment is also a major loss pathway. Most other sources and losses are generally minor. However, the pool of PCBs cycling between the sediment and water column through resuspension and settling is substantial. The PCB inventory suggests that a large reservoir of PCBs still exist in the upper level of sediment.

Model forecast scenarios to evaluate alternative futures are provided in Figure 7-9). Scenarios are provided for 5 to 6-year old lake trout at Sturgeon Bay.

Removing Contaminated Sediments at Ruddiman Creek and Ruddiman Pond

Ruddiman Creek and Ruddiman Pond are part of the Muskegon Lake “Areas of Concern” . Contaminants are present at high enough concentrations that they can affect human health, wildlife and aquatic life. Currently the main branch of Ruddiman Creek is posted as a no swimming, fishing or recreation area due in part to contaminated sediment. EPA and Michigan DEQ, in partnership with the AOC local public advisory council, have developed a contaminated sediment removal and site cleanup project for the creek and the pond.

The $10.6 million project is expected to take nine months to remove about 80,000 cubic yards of contaminated sediment . Under the Great Lakes Legacy Act of 2002, $6.9 million, or 65 percent of cleanup costs, are paid for with federal funds. The other $3.7 million must be non-federal, in this case, funds from the state’s Clean Michigan Initiative.

The main contaminants of concern include cadmium, found in the sediment with a maximum level of 25 ppm; chromium, found at 5,900 ppm; PCBs, found at 6 ppm; and lead, found at 1,200 ppm. This project will remove a substantial amount of these contaminants: an estimated 2,800 pounds of cadmium, 320 pounds of PCBs, 204,000 pounds of chromium and 126,000 pounds of lead.

More information is available at: www.epa.gov/glnpo/glindicators/sediments/remediateb.html

Results are from the LM2 (toxic PCB) model and Lake Michigan Food Chain Model. For comparative purposes, lake trout PCB concentrations are provided from the monitoring program and the Lake Michigan Mass Balance Study at Sturgeon Bay.
The first scenario is a constant load condition which holds PCB load to the same as at the 1994-1995 levels. The constant load scenario can also be characterized as no further action. The constant load scenario forecast shows a decline starting from 1994-1995 as result of past management actions and cleanups, however, then responds to the constant load with fish tissue concentrations ultimately leveling off at about 2012.

A second forecast is provided which encompasses a range based upon two rates of atmospheric declines (slow and fast) with a decline in tributary loads. These ranges of decline over the past decade are from long term monitoring programs and are described in peer-reviewed literature. These scenarios assume that recovery from past actions and present pollution prevention efforts, as well as remedial activities, will continue at approximately the same pace as in the past. The forecast range indicates that continued decreases in lake trout tissue concentrations into the foreseeable future. The lowermost portion of the range decreases to a lake trout PCB concentration, lower than the Uniform Great Lakes Sport Fish Consumption Advisory Level of 0.05 ug/g (ppm), in the year 2039. This is the most optimistic forecast for lake trout PCB concentration recovery, given the assumptions of continued recovery rate. The uppermost portion of the range does not fall below the advisory level in the model forecast through the year 2055. It appears that a decline in PCB lake trout

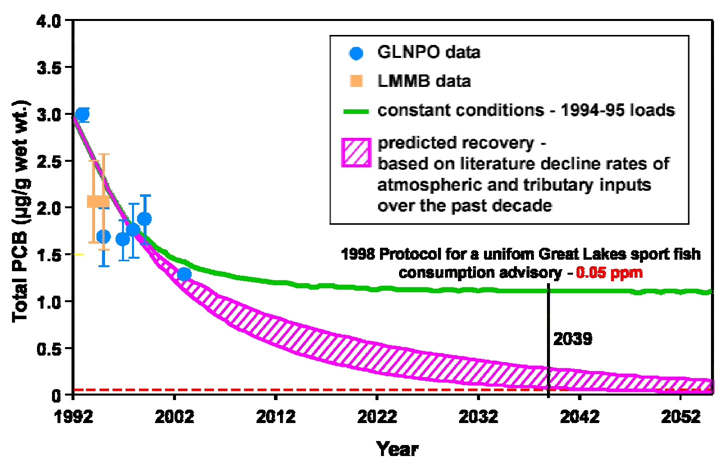


Figure 7-9. Predicted PCB Concentrations in Age 5.5 Lake Michigan Lake Trout at Sturgeon Bay

concentrations can be accelerated through management actions, for example, regarding pollution prevention efforts, land-based cleanups, and remediation of tributary sediments.

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 (Figure 7-10). 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.

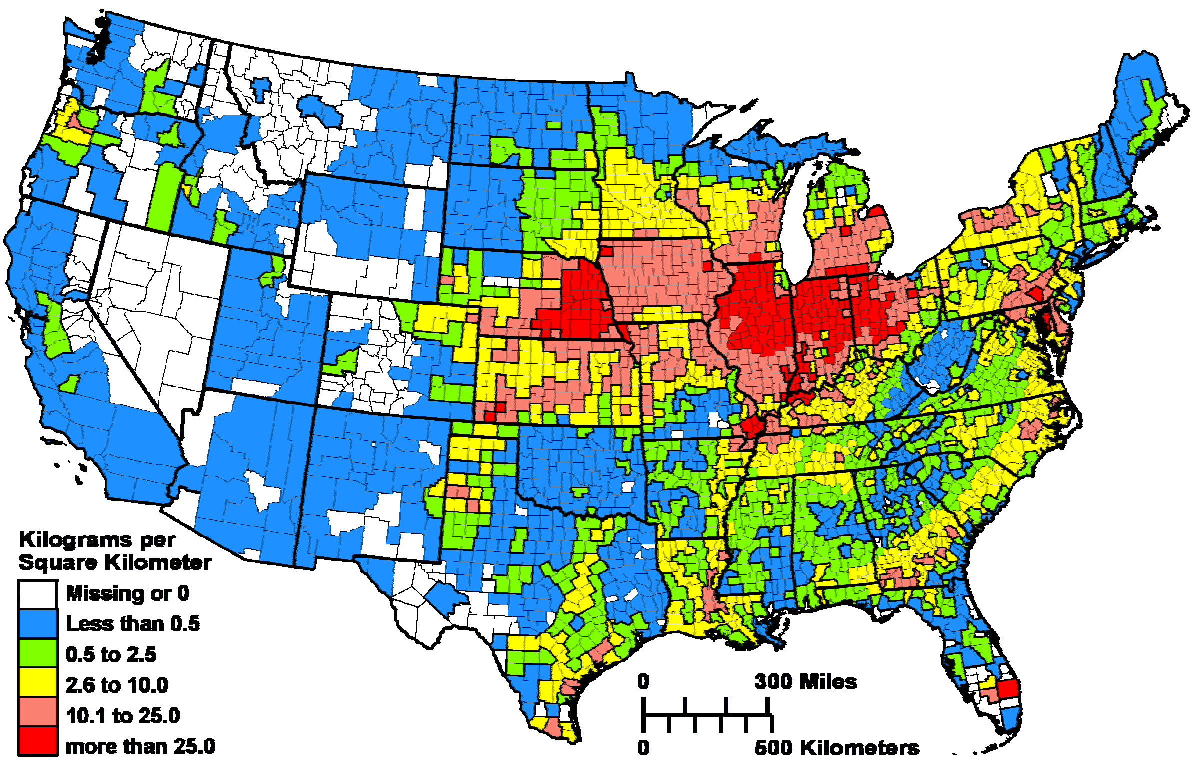


Figure 7-10. Atrazine Use- Kilograms per Square Kilometer (U.S. Geological Survey, 1991)

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). Historical loading estimates of atrazine from both tributaries and wet deposition to Lake Michigan are depicted in Figure 7-11. 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).

Tributaries are the most significant source of atrazine to the lake. Figure 7-12 illustrates atrazine loadings from the eleven major rivers monitored from the LMMB Study (Hall 2000a). The largest load of atrazine to the lake in 1994 and 1995 was the St. Joseph River followed by the Grand River.

In order to understand the impact of the atrazine loadings to Lake Michigan, a modeled mass balance was developed from the LM2 model (Figure 7-13). From these model results (Rygwelski et al. 1999; Rygwelski et al. 2006), one can note that the largest load to the lake is from the watersheds, followed by wet atmospheric deposition. Dry deposition to the lake is negligible. Input from Lake Huron and atmospheric absorption to the lake's surface are modest. The largest flux out of the system is the gross export to Lake Huron through the Straits of Mackinac. Export through the Chicago diversion and loss to the atmosphere through volatilization are small. In water, atrazine is primarily in the dissolved state and, therefore, any processes that involve sediment or suspended particle interactions are of minor significance.

The results from the modeling effort indicate the primary sources and pathways of atrazine within Lake Michigan. It also indicates that atrazine in water is

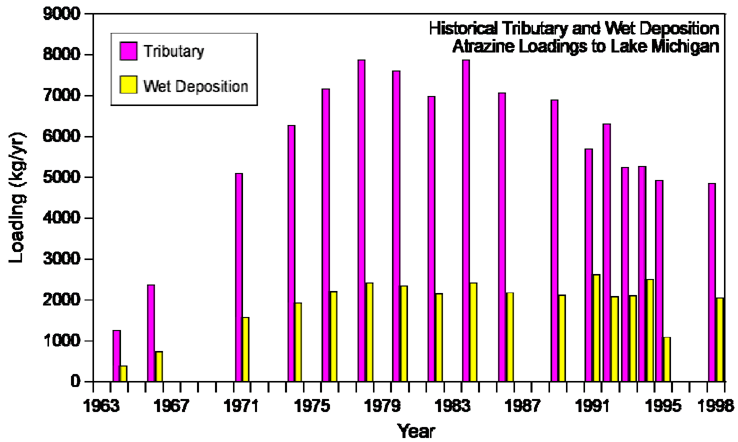


Figure 7-11. Historical Tributary and Wet Deposition Loadings of Atrazine to Lake Michigan.

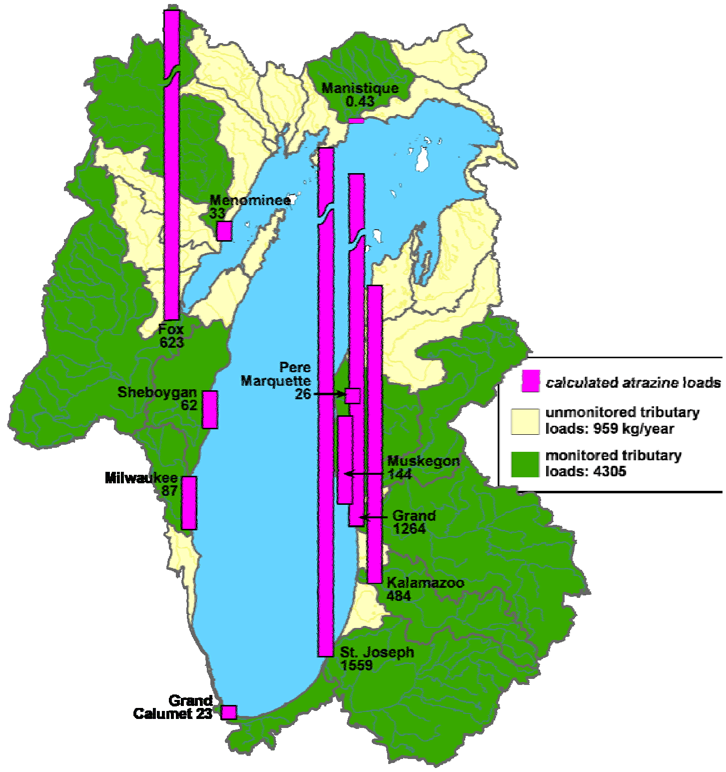


Figure 7-12. Atrazine loads (kg/yr) to Lake Michigan from major monitored and unmonitored tributaries, 1994-1995

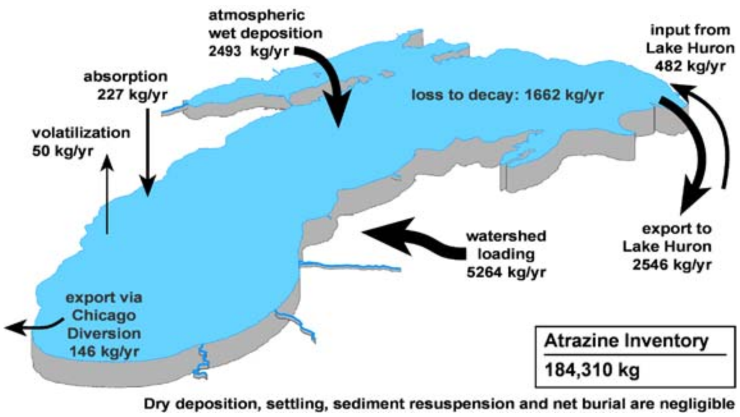


Figure 7-13. Lake Michigan Atrazine Mass Balance (including Green Bay) 1994

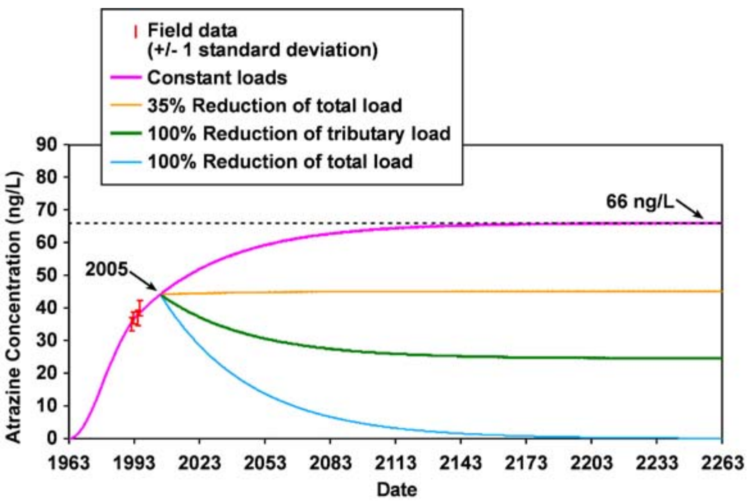


Figure 7-14. Lake Michigan Atrazine Forecasts (LM2 – Toxic Model)

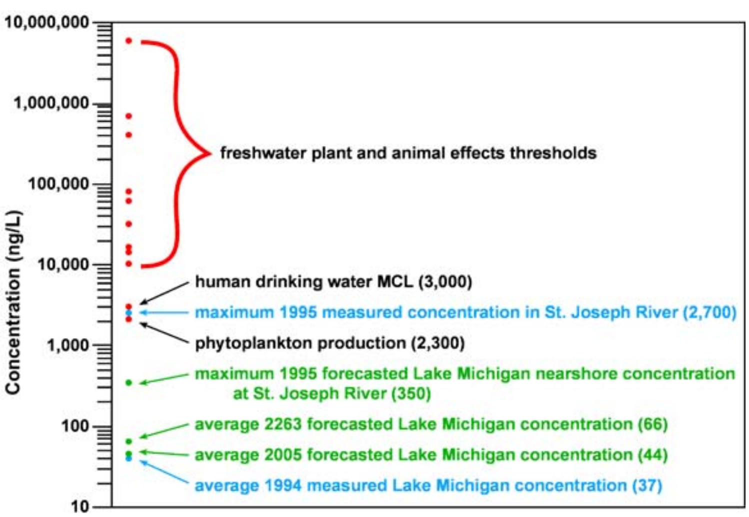


Figure 7-15 Atrazine Effects Thresholds Compared to Observations and Model Predictions

decaying only at an estimated rate of less than 1% of the total water column inventory. This translates into a half-life which exceeds 50 years. The literature suggests that atrazine decay is moderately rapid on soils and is can be at a moderately fast rate in shallow, warm freshwater systems that have high suspended solids, high dissolved organic carbon, low pH, and high concentrations of nitrate ions. The cold, deep, high pH, oligotrophic waters of Lake Michigan, together with a long retention time, do not appear to support considerable decay of atrazine.

Long-term simulations under various loading scenarios from LM2 are depicted in Figure 7-14. The constant load scenario (all loadings set at the 1998 loading level) indicates that the lake wide concentration continues to increase fairly rapidly through the end of the century and levels to 66 ng/L after the year 2200. This scenario can be regarded as the no action scenario. To maintain the lake concentration observed at the present (no further degradation), the second scenario indicates that a total load reduction (tributary and atmospheric) of 35% would be required. Two additional scenarios are also provided which show the response of Lake Michigan to 100% reductions in tributary and total loads, respectively. These scenario concur with the previous finding of tributary and atmospheric load importance.

Results of LMMB atrazine measured data and modeling forecasts is compared to effects thresholds in Figure 7-15. Note that the thresholds are on a logarithmic scale and that additional effects thresholds are known but are at greater values than those presented in the comparison. The comparisons indicate that measured and forecasted lakewide concentrations of atrazine, all fall below the presently know effects thresholds. However, one measured concentration in the St. Joseph River in 1995 was greater than the threshold for phytoplankton production.

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.

Results of a dated sediment core provide a historical perspective of mercury in Lake Michigan (Figure 7-16). Results from a depositional basin indicate that concentrations of mercury peaked in the mid 1940s and have been declining since that time (USEPA 2001e).

A long term record of total mercury in Lake Michigan lake trout (USEPA 2001e; 2002a), from limited data, is provided in Figure 7-17. Similar to the mercury profile in sediment, greatest concentrations were observed in the 1970s, with lower fairly stable concentrations stable concentrations thereafter. However, all concentrations reported in the long term record for Lake Michigan are well above the target for unrestricted consumption (USEPA 2000). A further examination of lake trout and coho salmon collected during the LMMB Study, indicated that only a few of the samples collected were below the target for unrestricted consumption (Figure 7-18). Only the younger fish were below the target. Total mercury was detected in all of the fish samples collected for this study (USEPA 2001c; 2001e). Mercury concentrations in adult lake trout ranged as high as 396 ng/g and averaged 139 ng/g. In coho salmon, mercury

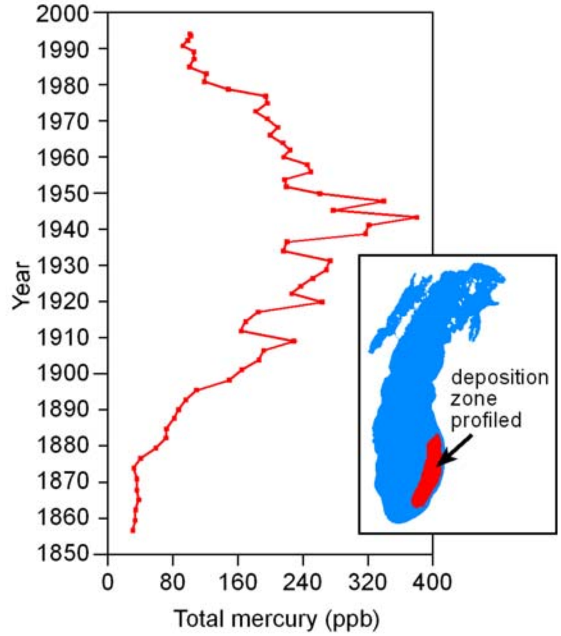


Figure 7-16. Sediment Profile of Lake Michigan Mercury.

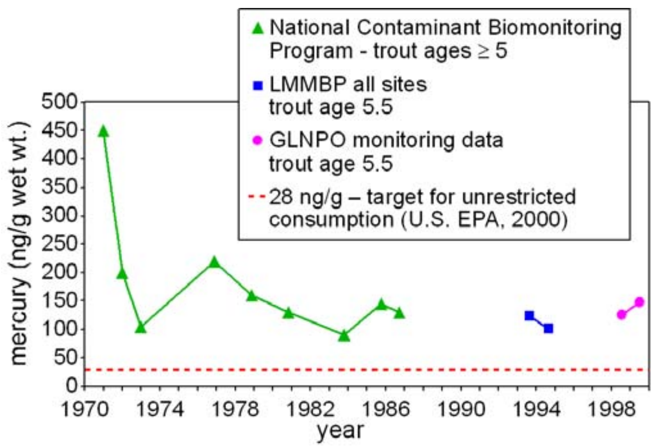


Figure 7-17. Total Mercury in Lake Michigan Lake Trout (Median of Composites).

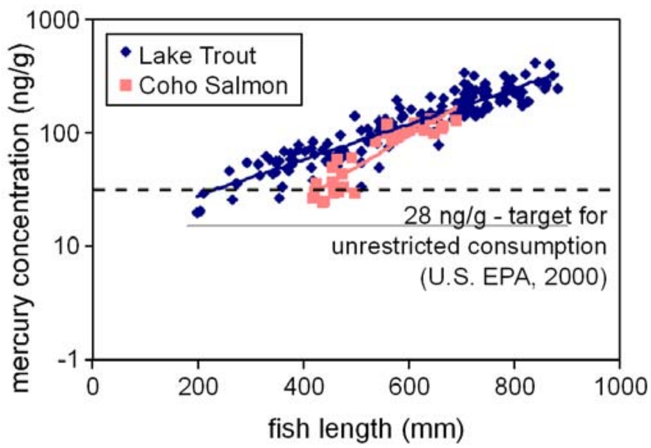


Figure 7-18. Relationship of Fish Length and Mercury in Lake Michigan (1994-1995).

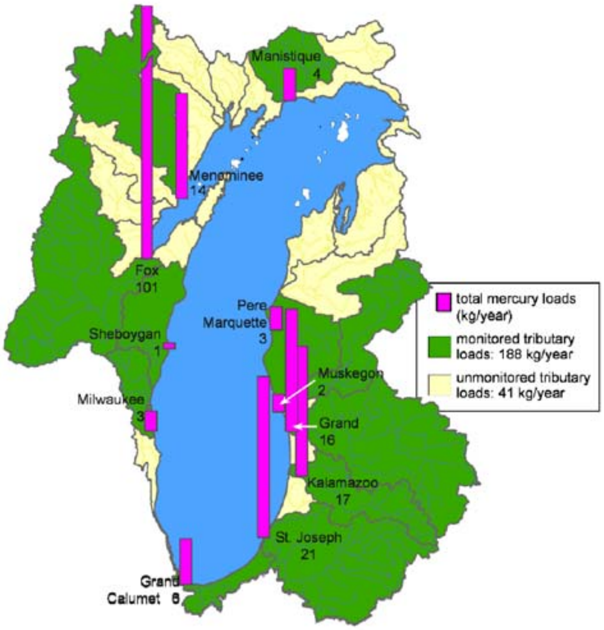


Figure 7-19. Total mercury loads (kg/year) to Lake Michigan from major monitored and unmonitored tributaries.

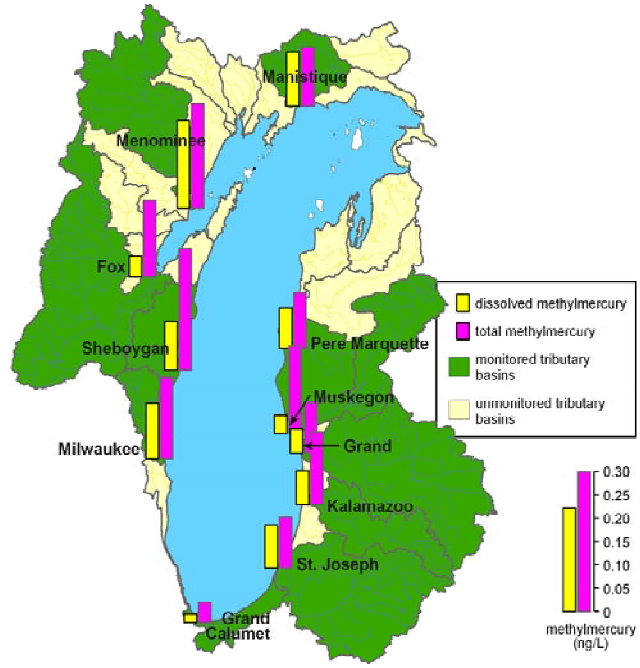


Figure 7-20. Dissolved and Total Average Methylmercury Concentrations in Monitored Tributaries.

concentrations ranged as high as 127 ng/g and averaged 79.9, 20.6, and 69.0 ng/g in hatchery, yearling, and adult salmon, respectively. Mercury concentrations in lake trout were significantly higher than in adult or yearling coho salmon. Adult coho salmon also were significantly higher in mercury concentrations than yearling coho, which contained the lowest mean concentration of mercury (USEPA 2001c).

The loadings of total mercury from the major monitored and unmonitored tributaries are provided in Figure 7-19. The total mercury load from tributaries is approximately 230 kg/year. The greatest load of total mercury is contributed by the Fox River. Other tributaries such as the St. Joseph, Kalamazoo, Grand, and Menominee Rivers generally contributed comparable loads to Lake Michigan, but considerably less than the Fox River (Hall and Robertson 1998; Hall 2000d).

Dissolved and total average methylmercury concentrations have been measured because methylmercury is believed to be the most bioavailable form of mercury to fish and to supplement the total mercury analyses of the LMMB Study (Hurley 2004). Methylmercury concentrations at the rivermouths of the major monitored tributaries is provided in Figure 7-20. Generally, methylmercury concentrations are fairly consistent over all tributaries,

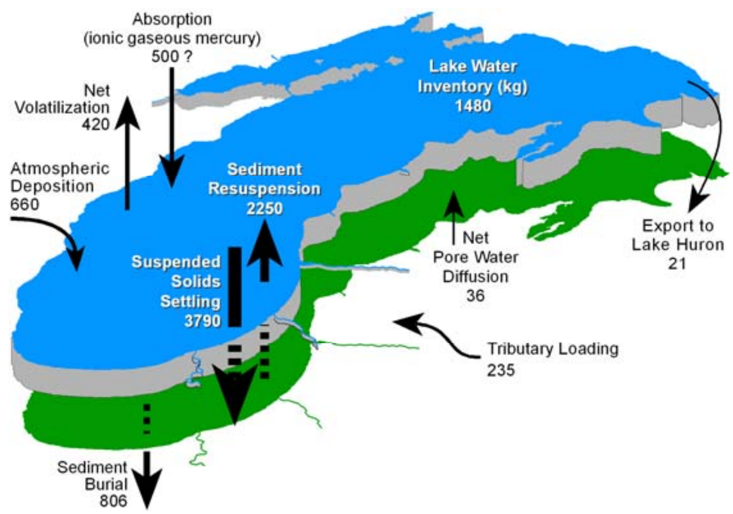


Figure 7-21. Total Mercury Mass Balance for 1994-1995.

with the exception of the Grand Calumet. Wetlands are known to convert total mercury to the methyl form and it is believed that the many of the riverine systems in the northern sector of the basin have a greater proportion of wetlands in their watersheds.

A screening level, Level 1 model, was conducted to examine the mass balance of total mercury in Lake Michigan (Ambrose et al. 1993; Zhang and Rygwelski 2000). As in other mass balance constructs, atmospheric and tributary loading are the primary external loads and the primary losses are volatilization, outflow, and sediment burial. Total mercury enters the system in both ionic and organic forms. Methylation and demethylation are modeled in both the water column and sediment. Particle setting and resuspension, as well as diffusive exchange are accounted for between these two media.

A schematic showing the results of the total mercury mass budget of Lake Michigan is given in Figure 7-21 (See preceding page). Results indicate that the greatest input of mercury to Lake Michigan from external sources is via atmospheric deposition, followed by tributary loading. Although not measured in this study, it is believed that absorption of ionic gaseous mercury to the surface of the lake is a considerable input and would even further increase the total loading through atmospheric sources. A large reservoir of total mercury exists in the sediment and a very large internal flux of mercury from the sediments to the water column can be observed. The greatest loss of total mercury from the system is from permanent sediment burial, followed by a considerable loss through net volatilization back to the atmosphere.

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.

Reducing Sediment by Stabilizing Stream Banks in Michigan's Big Sable River

The Michigan Department of Environmental Quality (DEQ) awarded the Conservation Resource Alliance (CRA) a Clean Michigan Initiative (CMI) grant of $142,000, and the CRA committed $48,000 in matching funds, for a project to reduce sediment inputs to the Big Sable River by stabilizing eroding stream banks and repairing eroding stream crossings, from October 2000 through September 2003. Excess sediment had been identified as a concern in the DEQ approved watershed management plan. The Big Sable River flows 24 miles through Lake and Mason counties, draining 178 square miles and discharging to Hamlin Lake north of Ludington.

Project accomplishments included the following:

- Six stream banks and one road crossing were repaired reducing sediment by 109 tons per year.
- The project facilitated the creation of a restoration committee that continued beyond the project. Approximately 150 people are on the committee mailing list and quarterly meetings commonly have 20 people in attendance.
- A $1,000 award from the local Fin and Feather Club was used to purchase 10 in-stream temperature data loggers that were used for a watershed temperature analysis. Data are collected by volunteers and the effort is expected continue for several more years.
- The Michigan Department of Natural Resources modified fish planting techniques in the Big Sable River. Committee members constructed fish distribution boxes so trout could be planted over a long stretch of river.
- The CRA established a Big Sable endowment fund under their River Care Fund program.
- The project created a strong link between the river restoration committee and the Hamlin Lake Improvement Board.

More information is available at: www.deq.state.mi.us/documents/deq-ess-nps-big-sable-fact-sheet.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 is the primary limiting nutrient in the Great Lakes and if loads and concentrations are sufficiently great, nitrogen and silica become secondarily limiting nutrients. Some of the symptoms of nutrient over-enrichment include excessive algal growth, species composition changes, taste and odor problems, and changes in aesthetics, among others.

The eutrophication model is an important component of the Lake Michigan mass balance modeling framework to examine relationships between nutrients and algal production but also for hydrophobic contaminants, because it simulates the dynamics of a significant sorbent particle class (phytoplankton) in the water column. For this reason, the eutrophication model was applied as part of the overall modeling framework for toxics. It generated and accounted for the different forms of carbon and thus coupled toxics and nutrients via eutrophication/ carbon sorbent modeling frameworks (USEPA 1995; 1997a; 1997b; 1997d; 1997e; Richardson et al. 1999; USEPA 2001d). The eutrophication model has also been applied as a stand alone model to specifically examine nutrient and phytoplankton relationships, provide a phosphorus mass balance, and alternative futures using model forecasts.

Total phosphorus has been measured and monitored in the Great Lakes due to its' importance in algal nutrient dynamics, algal species composition, and in the formation of hypoxia (USEPA 2002b). The long-term phosphorus loading record to Lake Michigan is provided in Figure 7-22 (IJC 1989; D. Dolan, personal communication). The record indicates very high phosphorus loads during the 1970s through 1980, with considerably lower total phosphorus loads since that time. The high loads observed in the 1970s exceeded the Great Lakes Water Quality Agreement (GLWQA 1987) target of 5600 mt/year; whereas more recent loading data suggests loads below and the target and in many cases, substantially lower. In response to the trend in phosphorus loads, total phosphorus in the offshore waters of Lake Michigan (USEPA 2002b) has exhibited a similar trend (Figure 7-23). In particular, total phosphorus concentrations have been below the International Joint Commission (IJC 1980) target of 7.0 ug/L for most of the period of record and have primarily ranged between 4.0 and 6.0 ug/L.

Phosphorus loads to Lake Michigan as determined during the Lake Michigan Mass Balance Study (Hall and Robertson 1998; Hall 2000b; 2000c) are provided in Figure 7-24. The Fox River contributed the greatest

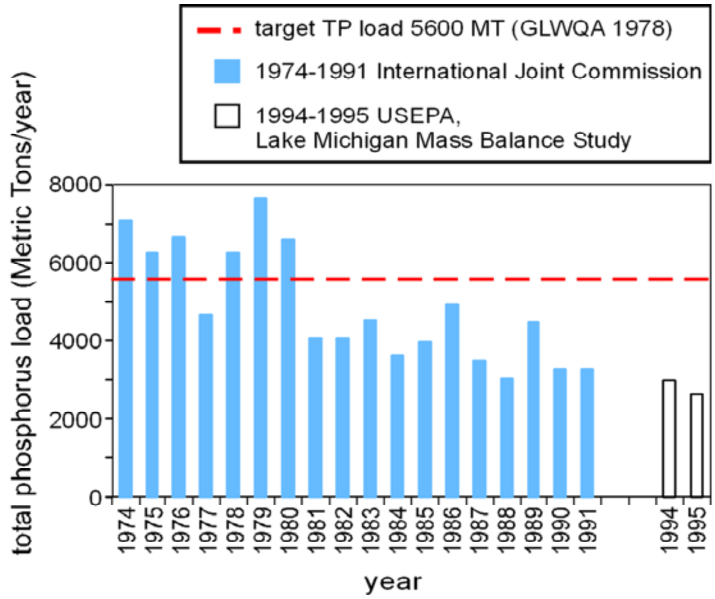


Figure 7-22. Historical Lake Michigan Annual Phosphorus Loading.

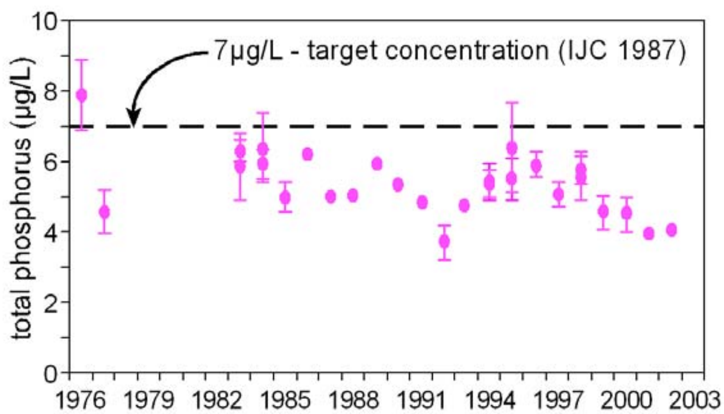


Figure 7-23. Lake Michigan Whole Lake Total Phosphorus – USEPA Great Lakes National Program Office (1974-2002).

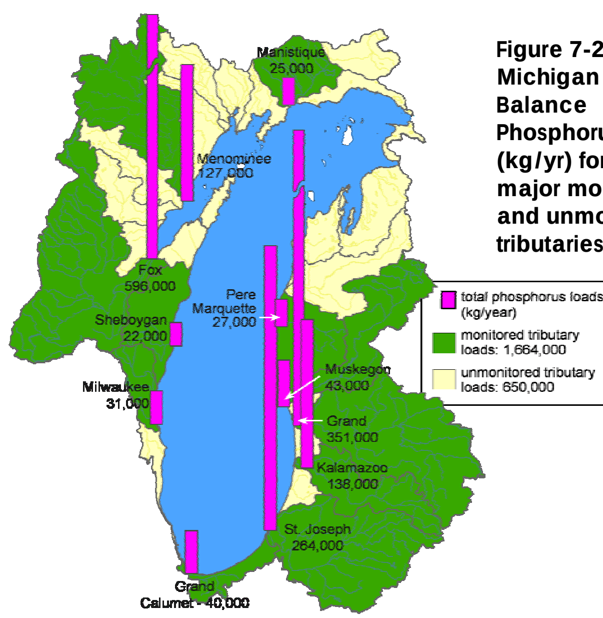


Figure 7-24. Lake Michigan Mass Balance Phosphorus loads (kg/yr) for the major monitored and unmonitored tributaries, 1995.

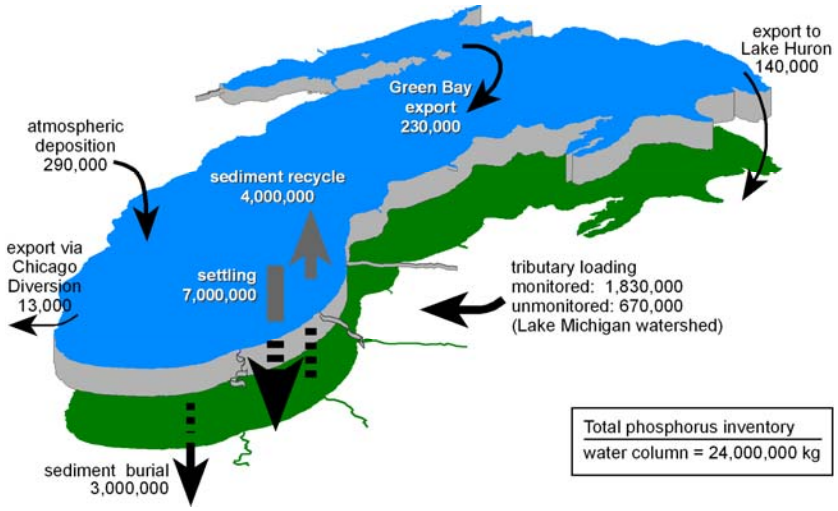


Figure 25. 1994-1995 Lake Michigan Total Phosphorus Mass Balance (kg/year).

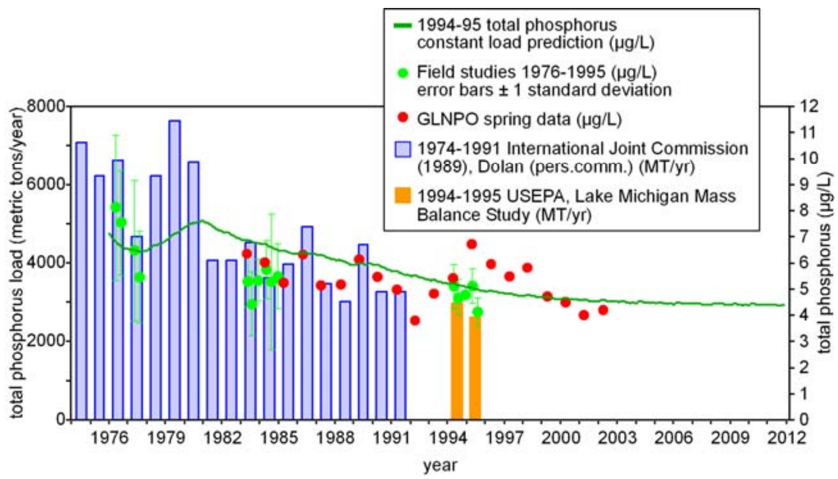


Figure 26. Total Phosphorus Model Prediction 1976-2011 and Annual Lake Michigan Phosphorus Loads 1974-1995.

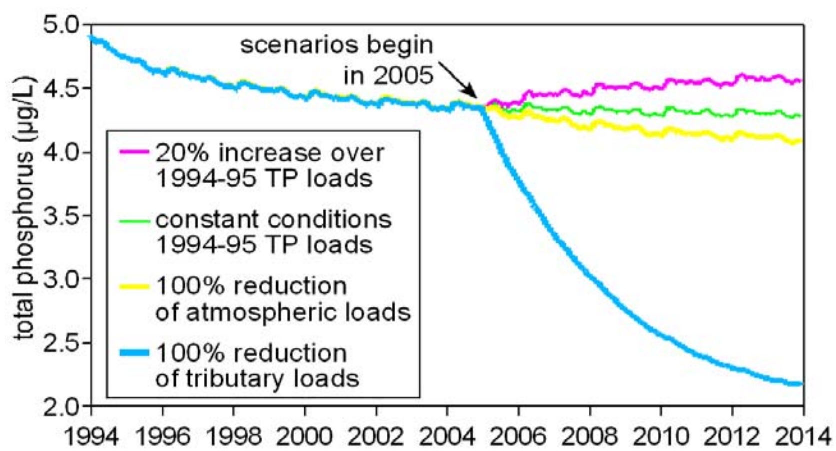


Figure 27. Lake Michigan Total Phosphorus Forecasts.

total phosphorus load to Michigan. Other tributaries with sizeable phosphorus contributions were the Grand and St. Joseph Rivers followed by the Kalamazoo and Menominee Rivers.

The modeled total phosphorus mass balance for Lake Michigan (1994-1995) is presented in Figure 7-25 (Rodgers and Salisbury 1981; Ambrose et al. 1993; USEPA 2004; Pauer et al. 2006). Results indicate that phosphorus is a traditionally-delivered substance with the greatest loads being contributed from tributaries. Atmospheric deposition (Miller et al. 2000) of phosphorus is only about 10% of the total load. The primary loss of phosphorus is through deep burial to the sediments; losses through the Straits of Mackinac and the Chicago diversion are relatively smaller. Of particular note is the large mass of phosphorus which cycles between the water column and sediments through resuspension and deposition, and a fairly sizeable load which enters the main lake from Green Bay.

A 20-year model hindcast and a forecast for total phosphorus concentrations through the year 2011 is presented in Figure 7-26. The hindcast-forecast is plotted along with total phosphorus loads and offshore Lake Michigan total phosphorus concentrations for reference. The model hindcast agrees reasonably well with measured total phosphorus concentrations, given the inter-annual variability of the measured data. The hindcast generally agrees with the decreasing trends exhibited by total phosphorus concentrations and annual lake-wide loads. The forecast uses a constant load scenario, equivalent to holding loads the same as measured in 1994-1995 into the future. The resulting forecast indicates very stable total phosphorus concentrations into the foreseeable future.

Further Lake Michigan total phosphorus concentration forecasts (2005-2014) are presented in Figure 27. In these forecasts, alternative futures are examined using different total phosphorus loading scenarios starting in the year 2005. The base line or constant load scenario (held at 1994-1995 loads) shows very stable phosphorus concentrations into the future. A 20% increase in load scenario is shown which would increase the total phosphorus concentration from approximately 4.3 to 4.6 ug/L in 2014, compared to the constant load scenario. Similarly, a scenario which reduces atmospheric load by 100%, exhibits a decrease in total phosphorus of approximately 4.3 to 4.2 ug/L. The last scenario represents a 100% decrease in total phosphorus loading from tributaries and exhibits a substantial decrease in total phosphorus concentrations by the year 2014. The forecast scenarios examining the 100% reductions in atmospheric and tributary loads, respectively, indicate that the model forecasts are consistent with the relative magnitude of loading from each source category.

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
- Groundwater

Coordinating Phosphorus Reduction in the Kalamazoo River/Lake Allegan Watershed

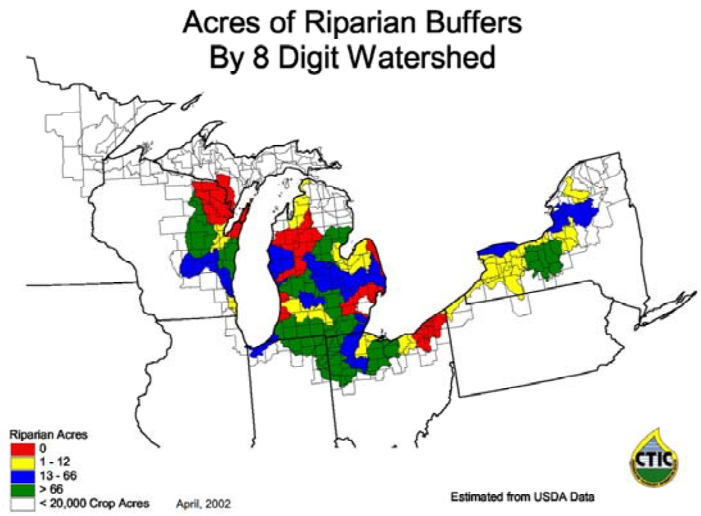
Excessive phosphorus in waterways can increase the growth of algae, decreasing the amount of oxygen in the streams, causing fish and other aquatic life to die.

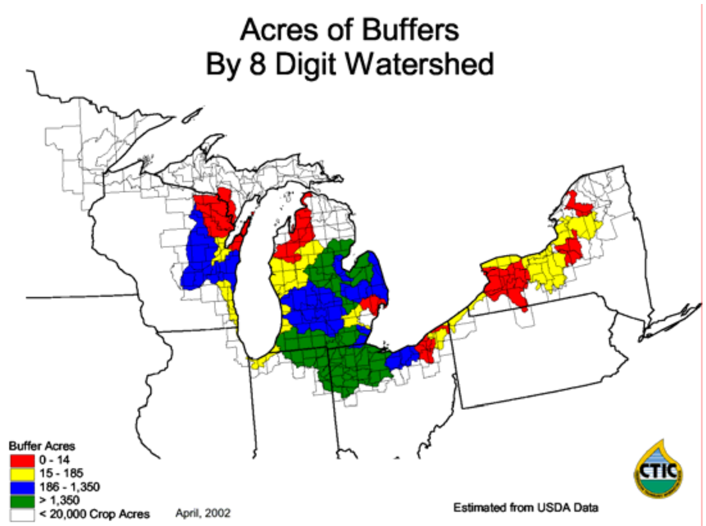
Stakeholders in the Kalamazoo River/ Lake Allegan watershed came together between 2001 and 2005 to coordinate their efforts to reduce phosphorus loads in the watershed. The waterways are impaired and required a Total Maximum Daily Load (TMDL) model that identified safe target phosphorus levels. The project used the TMDL as a starting point to reduce pollution from the multiple, hard to trace sources. It included coordination, communication and education efforts for extremely multi-faceted implementation activities of the Kalamazoo River/ Lake Allegan phosphorus TMDL. A TMDL Implementation Committee coordinated these efforts. Accomplishments include:

The Implementation Committee
Source: www.deq.state.mi.us/documents/deq-ess-nps-kazoo-lake-allegan.pdf

- Michigan State University Extension (MSUE) organized and facilitated the TMDL Implementation Committee, Leadership Team and 17 subcommittees.
- Stakeholder-led subcommittees are continuing discussions and developing strategies for phosphorus reduction.
- General education campaign increased awareness of Kalamazoo River/Lake Allegan issues and the TMDL.
- Kanoe the Kazoo involved hundreds of stakeholders and watershed residents. The event gained excellent media attention, helping to emphasize issues as well as the river's recreational value.
- During Super Soils Saturday, hundreds of landowners tested their soil and learned about phosphorus issues.
- A web-based tracking system, www.kbs.msu.edu/kzoonps, includes information and data about phosphorus reduction activities in the watershed.
- A day-long workshop was conducted to explore alternatives for organizing on a watershed basis to sustain TMDL and other conservation efforts.

More information is available at: www.deq.state.mi.us/documents/deq-ess-nps-kazoo-lake-allegan.pdf





Source: Conservation Technology Resource Center, Midwest No Till/Buffers Project

Buffers and Other Nonpoint Pollution Management Strategies

Filter or buffer strips are land areas of either planted or indigenous vegetation, situated between a potential, pollutant-source area and a surface-water body that receives runoff. Runoff may carry sediment and organic matter, and plant nutrients and pesticides that are either bound to the sediment or dissolved in the water. A properly designed and operating filter strip provides water-quality protection by reducing the amount of sediment, organic matter, and some nutrients and pesticides, in the runoff at the edge of the field before runoff enters the surface-water body. Filter strips also provide localized erosion protection since the vegetation covers an area of soil that otherwise might have a high erosion potential.

Installation of buffers is just one strategy for protecting waterways from pollutants. In areas where drain tile is used to drain fields of wetlands to increase the size of arable land, pollutants drain underneath buffers and directly into waterways, carried by stormwater runoff.

Use of no-till or low-till planting and effective application of pesticide and fertilizer management programs are other ways to protect water sources from pollution.

The GLRC has called for 335,000 new buffer acres, based on land drainage equals approximately 77,050 new acres in the Lake Michigan basin. See Chapter 4 for more information.

More information is available at: www.ctic.purdue.edu/CTIC/BuffersProject/index.html

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. These controls were required to be in place by 2003 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 1,000 beef cows, are now addressed through National Pollutant Discharge Elimination System (NPDES) permits under the authority of the Clean Water Act. About 5 percent of all animal feeding operations are expected to need permits.

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.

GLRC

Great Lakes Regional Collaboration Recommendations

Areas of Concern

The United States identified the 31 most contaminated locations on the Great Lakes under the Great Lakes Water Quality Agreement with Canada more than 15 years ago. None of them have been restored to date. To remedy this situation, a dramatic acceleration of the cleanup process at these **areas of concern** (AOC) is needed. The actions recommended are:

- amend the Great Lakes Legacy Act to increase funding and streamline the process;
- improve federal, state, and local capacity to manage the AOC cleanups;
- create a federal-state AOC coordinating committee to work with local and tribal interests to speed cleanups; and
- promote clean treatment and disposal technologies as well as better beneficial use and disposal options.

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

From 1997-2004, approximately 3.7 million cubic yards of contaminated sediment were remediated from the U.S. Great Lakes Basin. Results from a survey of all Great Lakes States indicates that roughly 76 million cubic yards of contaminated sediment remain in 77 sites within 25 Great Lakes AOCs. Estimated costs to remediate this amount range from $1.6 billion to $4.4 billion.

It is apparent that while significant progress has been made to date, much more work needs to be done. To address this problem, Congress passed the "Great Lakes Legacy Act of 2002" (GLLA) on November 12, 2002 and President George W. Bush signed the Legacy Act into law on November 27, 2002 (Public Law No. 107-303). The GLLA authorizes $50 million annually for fiscal years 2004-2008 for contaminated sediment remediation projects and provides USEPA with a unique approach for addressing contaminated sediment problems in Great Lakes AOCs. 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.

The GLLA also authorizes $3 million to conduct research on the development and use of innovative approaches, technologies, and techniques for the remediation of contaminated sediments in AOCs. Additionally, the Act also authorizes $1 million to carry out a public information program to provide information relating to the remediation of contaminated sediment to the public in AOCs.

Congress appropriated $9.9 million to the GLLA in FY04, $22.3 million in FY 05, and $29 million in FY 06. The FY 07 President's budget request calls for $49.6 million. As of March 1, 2006 GLNPO has obligated all of the FY 04 funds and either committed or obligated approximately 45% of the FY 05 funds. USEPA anticipates expended the remaining 55% of these funds by September 06.

One of the key objectives outlined in the 2002 Great Lakes Strategy, is to "accelerate the pace of contaminated sediment remediation, working to overcome barriers to progress identified at each site. Bringing together complementary Federal and State authorities, and/or government and private resources to address the contaminated sediment problem and its sources, so that by 2025, the cleanup of all known sites in the Basin will be completed." We believe that with the Great Lakes Legacy Act, USEPA now has a program in place that can make steadier progress toward addressing the 77 sites and 76 million cubic yards of contaminated sediment in the Great Lakes Basin.

This GLLA implementation plan directly supports the following strategic targets of the Agency's Strategic Plan:

Cubic yards (in millions) of contaminated sediment remediated in the Great Lakes. Every cubic yard of sediment remediated through the Legacy Act supports this target. Other programs in the Agency, which contribute toward this target, make significant contributions; however, they are not focused specifically on this target. Their contributions vary significantly from year to year. Reporting in 2007 is expected to show that USEPA and its partners will have remediated a cumulative total of 4.2 million cubic yards of contaminated sediments since tracking began in 1997. Remediation from GLLA projects will contribute to this growing total. 200,000 cubic yards were remediated through the Legacy Act in 2004 and 2005, and USEPA estimates that in 2006 and 2007, GLLA projects will remediate over 650,000 cubic yards of contaminated sediments.

Restore and delist AOCs within the Great Lakes basin. The GLLA targets resources to clean up contaminated sediments, a significant source of Great Lakes toxic pollutants that can impact human health via the bioaccumulation of toxic substances through the food chain. Contaminated sediments are the cause of or significantly contribute to as many as 11 of the 14 impairments to beneficial uses (including restrictions on fish consumption due to high contaminant levels in fish tissue) in AOCs. Most AOCs can thus not be de-listed without first addressing the contaminated sediments which are contributing to their beneficial use impairments.

Periodically starting in 2006, GLNPO proposes to develop a fresh Request for Projects, soliciting new GLLA projects. GLNPO will thus be best positioned to ensure that all potential projects have a fair opportunity to be considered, whether or not they directly result from direct contact with GLNPO staff. More information is available at www.epa.gov/glnpo/legacy.

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.

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 control and pollution control measures
- 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 will be updated for Legacy Act funding or delisting opportunities
- Investigate nutrient contributions from the agricultural sector and non point sources during wet weather. Determine if nutrient levels are linked to *Cladophora* blooms
- Hold meetings to discuss Lake Michigan Mass Balance models and implications for Impaired Waters Strategy
- Develop Impaired Waters Strategy through basinwide meeting

Great Lakes Regional Collaboration Goals and Recommendations Relevant to the Lake Michigan LaMP Subgoal 7

Persistent Bioaccumulative Toxics Goals and Recommendations

See Chapter 1 for specific recommendations.

Nonpoint Source Pollution Goals and Recommendations

Goals

Goal: Protect existing wetlands and restore wetlands in both urban and rural areas so that rivers, streams, and lakes across the Great Lakes region function as healthy ecosystems.

Interim Milestones:

- By 2010, restore, recover, and protect a net increase of 550,000 acres of wetlands within the Great Lakes basin.
- By 2015, restore, recover, and protect a net increase of 1,000,000 acres (450,000 additional) of wetlands within the Great Lakes basin.

Goal: Measurably reduce at least hundreds of thousands of tons of sediment, pounds of phosphorous loading, and pounds of nitrogen loading in to the Great Lakes basin.

Interim Milestones:

- By 2010, create 335,000 new acres of buffer strips within the Great Lakes basin.
- By 2020, create 1,000,000 new acres (665,000 additional) of buffer strips within the basin.

Goal: Reduce the amount of sediment reaching the Great Lakes through installation and continued use of management practices on cropland, especially those that increase crop residue left on the surface.

Interim Milestones:

- By 2010, have 2,000,000 new acres of Great Lakes basin cropland under appropriate residue management. This increase corresponds to 40 percent decrease in soil loss.
- By 2015, extend to 2,800,000 new acres (800,000 additional new acres) of Great Lakes basin cropland under appropriate residue management.

Goal: Reduce livestock agriculture's contribution to nonpoint source loading by 40-70 percent through comprehensive nutrient management planning (CNMP) and practice implementation.

Interim Milestones:

- By 2008, 70 percent of all livestock farmers will attend education programming regarding nutrient management.
- By 2010, all acreage utilized for livestock production in a major phosphorous-impaired Great Lakes watershed in each Great Lakes State will be covered by certified CNMPs.
- By 2010, triple the number of certified CNMP providers in the basin that directly assist farmers.
- By 2015, 70 percent of all livestock production in the U.S. portion of the Great Lakes basin will be covered by certified, phosphorous-based CNMPs.

Goal: Improve flow regimes to meet sediment reduction goals and restore sustainable biological communities.

Interim Milestones:

- By 2010, in all watersheds classified as severely or moderately impacted based on degree of altered hydrology and ecological sensitivity using scientifically defensible indicators: develop better understanding of baseline conditions (appropriate time frame, natural vs. human influences) and relationship between stressors and ecological endpoints (water quantity as stressor, effectiveness of BMPs, cumulative impacts); develop appropriate assessment criteria (numeric vs. narrative; relate to societal values); develop/refine new methods (decision support systems, monitoring technology); and apply most strategic remediation alternatives to foster goal of restoring natural flow regime.
- By 2015, restore/manage the hydrologic regime in ten select watersheds to restore sustainable biological communities and reduce excessive

sediment loadings.

- By 2020, document improvements in: measurable changes in hydrology (reduction in peak flow and volume); measurable reduction in bank erosion and sediment loading; and measurable improvement in the health of the biological community in significant portions (stream orders 1-3) of ten urban watersheds and/or sediment loading into areas where these watersheds discharge to the Lakes.

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Recommendations

In general, programs need coordination at a higher level and a focus on mitigating specific problem areas, such as Areas of Concern. Although agencies offer grants to states, tribes, and local groups to address these concerns, the grants are given without any overall, interagency focus or strategy. Effectively targeting and addressing problems will require not only federal agency budget enhancements, but also coordination of efforts and data so that agencies at all levels concentrate their energies on the same priority problems. To this end, the NPS Strategy Team suggests designating or establishing an organization to coordinate efforts, roles, and initiatives among federal, state, and local agencies and private organizations in the Great Lakes basin.

1. **Between $77 million and $188.7 should be provided annually over five years to fund restoration of 550,000 acres of wetlands.**

2. **$335 million should be provided to restore 335,000 acres of buffers over five years.**

3. **$120 million should be allocated by 2010 to achieve a 40 percent reduction in soil loss in ten selected watersheds.**
   Critical Geographies: Land areas draining to western and central Lake Erie, the Maumee River watershed, Green Bay, Saginaw Bay, Lake St. Clair, nearshore waters of Lake Michigan, and AOCs.

4. **$106 million in funding should be provided to support the development and implementation of comprehensive nutrient and manure management on livestock farms.**

5. **$18 million should be provided annually over five years to hydrologically improve ten urban watersheds of various sizes.**
   Critical Geographies: The new program should focus on urbanized areas where runoff from development and the associated impairments directly affect natural waterways and their confluence with the Great Lakes or connecting waters. Likely candidates include smaller watersheds or sub-watersheds within the Duluth, Milwaukee, Green Bay, Gary, Detroit, Cleveland, Toledo, and Buffalo metropolitan areas.

Areas of Concern Goals and Recommendations

Goals

The goal of the Great Lakes Regional Collaboration is to restore all the U.S. Great Lakes AOCs.

Milestones toward this ultimate goal include:

- By the end of 2006, U.S. EPA should expand the existing U.S. EPA-State RAP Workgroup into a Federal-State AOC Coordinating Committee to better coordinate efforts and optimize existing programs and authorities to advance restoration of the AOCs;
- By the end of 2007, Congress should revise and reauthorize the Great Lakes Legacy Act;
- By the end of 2008, delisting targets for each U.S. AOC should be developed collaboratively by federal, state, local, and tribal partners;
- By the end of 2010, 10 AOCs should be delisted (restored to target goals); and
- By 2020, all known contaminated sediment sites in the AOCs should be remediated.
- Coupled with restoration measures identified in other chapters, this will facilitate complete restoration of the AOCs.

Recommendations

1. **Great Lakes Legacy Act Funding, Amendments, Reauthorization and Guidance**
   - Over the next five years, the Administration should request and Congress should appropriate $150 million annually for the Great Lakes Legacy Act to remediate contaminated sediment sites in the AOCs. Congress should amend the Legacy Act to allow for more efficient implementation of the program
   - The “maintenance of effort” language in the

Legacy Act should be dropped because it is not appropriate in the context of sediment remediation where costs often vary widely from year to year and, as a result, it can lead to inadvertent disqualification of otherwise eligible and valuable projects. The life of appropriated Legacy Act funds should be extended beyond two years (as envisioned by the Legacy Act) to accommodate both responsible remediation and long-term monitoring of the effectiveness of implemented remedies, which is consistent with the 2002 *Great Lakes Strategy*.

- The current 35 percent level of matching funds/ in-kind services required under the Legacy Act from the nonfederal sponsor at "orphan sites" should be adjusted to 25 percent, or at a minimum, Legacy Act funds should be available for planning and design work with no match or reduced match, in order to "tee-up" projects and maintain momentum.
- The current limitation in the Legacy Act which requires exclusive federal agency project implementation precludes disbursal of funds to other entities to assume the lead in project implementation. This requirement restricts the efficient implementation of remedial work in some cases, and should be amended to allow direct disbursal of project funds, which would allow for greater flexibility in implementing the program.

2. AOC Program Capacity

- The Administration should request and Congress should appropriate $10 million annually to the Great Lakes states and community-based coordinating councils in the AOCs; and $1.7 million to U.S. EPA's Great Lakes National Program Office for regional coordination and program implementation.
- Furthermore, the U.S. Army Corps of Engineers Great Lakes Remedial Action Plan Program, authorized in Section 401 of the Water Resources Development Act of 1990, should be included in the President's budget to enable the Corps to participate in the Federal-State AOC Coordinating Committee and to request funding for projects that advance restoration of the AOCs.

3. Federal-State Collaboration

- The existing U.S. EPA/State RAP Work Group should be expanded to a Federal-State AOC Coordinating Committee to better coordinate efforts and optimize existing programs and authorities to advance restoration of the AOCs.

4. Promote Development of Environmentally-Sound Sediment Treatment and Destruction Technologies, Beneficial Re-Use of Sediments, and Best Available Disposal Options.

- U.S. EPA, the U.S. Army Corps of Engineers, the states, and the tribes should actively examine innovative approaches to the ultimate disposition of contaminated sediments as an alternative to the current practice of disposing of them in Confined Disposal Facilities (CDFs) or landfills. Congress should fully fund, at $3 million annually over the next five years, the research and development program authorized in Section 306 of the Great Lakes Legacy Act.

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.

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 chemicals 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.

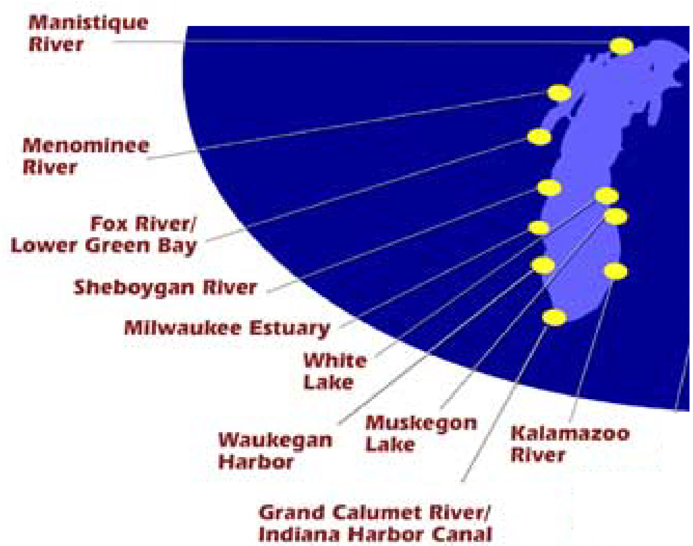
XI. **Degradation of aesthetics** - When any substance in water produces a persistent objectionable deposit, unnatural color or turbidity, or unnatural odor (e.g. oil slick, surface scum).

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



Lake Michigan Areas of Concern Summary Matrix **For more information, see http://www.epa.gov/glnpo/aoc**

AOC Name and BUIs	Primary Contaminants	Geographic Area	Stressors	Programs	Clean-Up Actions	Key Activity Needed	Challenges	Next Step
Grand Calumet River **Indiana** I, II, III, IV, VI, VII, VIII, IX, X, XI,XII, XIII, XIV	• PCBs • PAHs • Mercury • Cadmium • Chromium • Lead • Pathogens • Biochemical oxygen demand • Suspended solids • Oil and grease	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.	• Contaminated Sediments • Combined Sewer Overflows • Contaminated groundwater • Contaminated land sites • Habitat Fragmentation • Fire Suppression • ANS	• Superfund • RCRA • Clean Water Act • WRDA • Navigational Dredging • Natural Resource Trustee's Damage Assessment	• USX dredging • West Branch Remediation – 14,200 cubic yards of sediment remediated • U.S. Steel Gary Works dredging of 5 river miles on the East Branch complete. • GSD Sed. Remediation • Navigational dredging • LTV cleanup • 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 is including additional CSO requirements in discharge permits as they are renewed in the basin pursuant to a state CSO Strategy.	• Dredging • CSO Long Term Control Plans • Issue NPDES Permits • BUI Indicator Monitoring • TMDL underway • West Branch assessment • 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	• Dredging at USX complete • NRDA- Complete PRP negotiations. • ACOE- WRDA Diagnostic Feasibility Study • USX-Build Corrective Action Management Unit • GSD-Site Characterization • TMDL-Resolve modeling issues • Monitor BUI Indicators • ECI slurry wall • The RAP process has developed and obtained funds for a Toxic Pollution Prevention (TPP) Program

Lake Michigan Areas of Concern Summary Matrix

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AOC Name and BUIs	Primary Contaminants	Geographic Area	Stressors	Programs	Clean-Up Actions	Key Activity Needed	Challenges	Next Step
Kalamazoo River **Michigan** I, III, V, VI, VII, X, XI, XIV	• PCBs • Phosphorus • Sediments	From Morrow Dam, which forms Morrow Pond and extends 80 miles downstream to Lake Michigan.	• Nonpoint pollution • Sediments • Contaminated sediment landfills	• 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 • 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 sources • Remedial action at several Operable Units (OUs) along the river • Watershed management projects in several sub-basins reduce pollutant inputs and develop beneficial land use measures	• Dredging/ Excavation • Superfund site cleanup decision action • Stream buffers • Dam removal • Coordination with RAP program for AOC delisting purposes	• PRP court case • Local funding match for federal projects • Decisions on the remediation of this Superfund Site have effectively been on hold for the past several years	• Continue NRDA assessment • Finish remedial investigation/ remedial action • Investigate strategy and determine action • RAP to be revised in 2006 • Kalamazoo River/ Lake Allegan TMDL (Total Maximum Daily Load) program pursuing water-quality data collection
Lower Fox River/ Southern Green Bay **Wisconsin** I, III, V, VI, VII, VIII, IX, X, XI, XIII	• PCBs • Phosphorus • Suspended solids • Mercury	The lower 40 miles of the Fox River and Green Bay	• Urban and rural runoff • Sediments • Aquatic exotic species • Wetland loss • Habitat alteration	• Clean Water Act • Superfund • Natural Resource Trustee's Damage Assessment	• Watershed NPS abatement • Remedial investigation completed remedial action nearly ongoing. Dredging and PCB removal (Deposit in 7,200 cubic yards of sediment removed and Deposit 56/57: 50,000 cubic yards of sediment removed) • Dissolved oxygen wasteload • Deposit N, 56, 57 • Cumulative sediments remediated from 1997-2002 – 87,500 cubic yards • Consent Decree for Phase I Fox River clean-up announced 4/12/06	• Dredging • Pollution Prevention • Stream buffers • Habitat protection and restoration • Coordination with RAP program for AOC delisting purposes	• Rapid land development • Contaminated material disposal • Seeing through completion of cleanup for OUs 2-5	• Implement 4/12//06 Consent Decree • Removal of 10 million cubic yards of sediment. • Completed dredging and implementation of cleanup plan for OU 1, expected to take 3-6 years • OUs 2-5 final cleanup plan implementation, expected to take 15 years

Lake Michigan Areas of Concern Summary Matrix

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AOC Name and BUIs	Primary Contaminants	Geographic Area	Stressors	Programs	Clean-Up Actions	Key Activity Needed	Challenges	Next Step
Manistique River **Michigan** I, VI, VII, X, XIV	• PCBs • Heavy metals • Pathogens	The last 1.7 miles of the river to the mouth of the harbor at Lake Michigan	• Combined sewer overflow • Sediments • PCB-contaminated sawdust • Wastewater discharges	• Superfund	• Dredging of contaminated sediments completed in 2000 (190,000 cubic yards) • Manistique Wastewater Treatment Plant made improvements to its system toward elimination of CSOs	• Sampling and monitoring follow-up to confirm downward trends of contamination • Coordination with RAP program for AOC delisting purposes	• Navigational dredging • CSO to be closed by 2020 • Coordination with RAP program for AOC delisting purposes	• Sampling and monitoring continuing as part of delisting process
Menominee River **Michigan/ Wisconsin** I, III, VI, VII, X, XIV	• Arsenic • Mercury • PCBs • Oil and grease • Pathogens	Lower 4.8 km of river to the mouth and 5 km north and south of the mouth along the bay shore	• Sediments • Coastal wetlands habitat loss • Nonpoint pollution • Historic shoreline developments to support harbor activities	• RCRA Corrective Action • Superfund	• Arsenic remediation (33,000 cubic yards) • Combined sewer overflow project	• Dredging • Protect riparian and coastal habitat • Pollution prevention • Coordination with RAP program for AOC delisting purposes	• Woody debris is present at the WPSC Marinette MGP Site, which may have hindered accurate determination of the sediment thickness • Coordination with RAP program for AOC delisting purposes; bi-state coordination issues	• Arsenic dredging completed • Paint sludge deposit cleanup above river mouth
Milwaukee Estuary **Wisconsin** I, III, IV, VI, VII, VIII, X, XI, XIII, XIV	• Phosphorus • Pathogens • PCBs • Metals • PAHs	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	• Urban and rural runoff • Wastewater discharges • Sediments • Habitat loss • Dams	• Clean Water Act • Clean Air Act • Superfund • Brownfields • Navigational dredging	• Water pollution abatement • Pollution prevention education begun • Dam removal • 7,000 cubic yards remediated	• 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	• Complete assessment for Kinnickinnic River • Estabrook Impoundment remediation needed • Research into pathogen sources • Watershed analysis to assess water quality impacts and options for restoration

Lake Michigan Areas of Concern Summary Matrix **For more information, see http://www.epa.gov/glnpo/aoc**

AOC Name and BUIs	Primary Contaminants	Geographic Area	Stressors	Programs	Clean-Up Actions	Key Activity Needed	Challenges	Next Step
Muskegon Lake **Michigan** I, V, VI, VII, VIII, IX, XIV	• PCBs • Mercury	The entire 4149 acre lake and several tributaries.	• Sediments • Nonpoint pollution	• Brownfields • Navigational dredging • Great Lakes Legacy Act	• Wastewater treatment upgraded • Some tributary remedial actions underway • Removal of about 80,000 cubic yards of contaminated sediment in Ruddiman Creek	• Dredging • Stream buffers • More assessment • Coordination with RAP program for AOC delisting purposes	• PCB disposal • Local funding match for federal projects	• Remediation of brownfields and sediments • Complete assessment of contaminated sediment in Ryerson Creek and in Muskegon Lake at the Division Street Outfall.
Sheboygan River **Wisconsin** I, III, V, VI, VII, VIII, XIII	• Suspended Solids • PCBs • PAHs • Heavy Metals • Pathogens • Phosphorus	The lower Sheboygan River downstream from the Sheboygan Falls Dam, including the entire harbor and nearshore waters	• Industrial & agricultural runoff • Habitat restoration on streambanks and wetland areas	• Superfund • Clean Water Act #319	• Partial removal of PCB-contaminated sediments • Agency decision (2001) • 2004 Municipal stormwater permits for the Village of Kohler, Town of Sheboygan and Town of Wilson.	• 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 • Coordination with RAP program for AOC delisting purposes		• Complete dredging started in 2004 • Complete site clean-up and removal of preferential pathways • groundwater monitoring
Waukegan Harbor **Illinois** VI, VII, X, XIII, XIV	• PCBs	1.2 square kilometers of industrial, commercial, municipal and open lands.	• Sediments	• Superfund • Brownfields	• 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	• Dredging • Brownfield development • Habitat restoration • Coordination with RAP program for AOC delisting purposes	• Corps navigation dredging Phase II Sediment removal • Contaminated material disposal • Funding to fulfill local match for U.S. Army Corps of Engineers dredging of the shipping channel	• Final dredging and disposal of inner harbor extension sediments • OMC building clean up • Pursuit of a dredging plan for the removal of PCB contaminated sediments from Waukegan Harbor -- expected release of an Alternatives Analysis in early 2006 • 319 grant will develop watershed plan to reduce nonpoint source pollution and improve water quality in the Waukegan River watershed

Lake Michigan Areas of Concern Summary Matrix   For more information, see http://www.epa.gov/glnpo/aoc

AOC Name and BUIs	Primary Contaminants	Geographic Area	Stressors	Programs	Clean-Up Actions	Key Activity Needed	Challenges	Next Step
White Lake **Michigan** I, III, VI, VII, VIII, IX, XI, XIV	• Heavy metals • Stormwater nonpoint pollution • Arsenic • Chromium	Includes White Lake and a one-quarter mile wide zone around the lake.	• Sediments • Industrial contamination • Groundwater contamination	• Superfund • RCRA	• Dredging in ATannery Bay@ (2002) – 73,000 cubic yards of waste (hides, chromium, 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 discharge	• Assessment and further study of contaminated sites • Stream buffers • Coordination with RAP program for AOC delisting purposes	• Funding to pinpoint locations having greatest impact to eutrophication	• 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