United States Geological Survey
Programs in the Great Lakes

Fact Sheet

The USGS provides maps, reports, and information to help others meet their needs to manage, develop, and protect America's water, energy, mineral, and land resources. We help find natural resources needed to build tomorrow, and supply scientific understanding needed to help minimize or mitigate the effects of natural hazards and environmental damage caused by human activities. The results of our efforts touch the daily lives of almost every American.

The Great Lakes System

The Great Lakes system comprises Lakes Superior, Michigan, Huron, Erie, and Ontario and their connecting waterways—the St. Marys, the St. Clair, the Detroit, the Niagara, and the St. Lawrence Rivers; the Straits of Mackinac; Lake St. Clair; and the Welland Canal. The volume of water stored in the Great Lakes, which is about 6,020 trillion gallons, or 5,472 cubic miles, represents 20 percent of the world's and 95 percent of North America's fresh surface water. These surface-water resources and their role in commerce, tourism, and recreation (fig. 1) have attracted 40 million people to live in the Great Lakes Basin—about one-seventh of the total population of the United States and about one-third of the total population of Canada.

Contamination of the Great Lakes ecosystem limits recreation uses, threatens productivity of commercial and sport fisheries, and increases the cost of water-supply treatment. The U.S. Geological Survey (USGS) conducts geologic and hydrologic investigations, the results of which will help planners understand and implement strategies to help reduce point- and nonpoint-source contamination that threatens water quality in the Great Lakes.

Figure 1. Sleeping Bear Dunes National Lakeshore, Leelanau County, Michigan.

Toxic Substances

In 1983, the International Joint Commission—an organization established by the Boundary Waters Treaty of 1909 between the United States and Canada—reported that 900 chemicals and heavy metals that are potentially dangerous to human health and biota had been identified in the Great Lakes. Concern about the potential effects of these chemicals and metals has increased as evidence of links between the presence of contaminants and carcinogenicity in fish, genetic defects in fish-eating birds, and reproductive disorders in biota has increased. Further possible links have been reported between developmental disorders in human infants and prenatal exposure to contaminants through consumption by their mothers of certain fish from the Great Lakes.

The Commission has identified 43 Areas of Concern along the shoreline of the Great Lakes. Contamination by toxic substances, including polychlorinated biphenyls (PCB's), other synthetic organic compounds, trace elements in bottom sediments of rivers and harbors, and suspended-sediment inflow to the Great Lakes are specific water-quality problems in these areas. The USGS, in cooperation with numerous local, State, and other Federal agencies, is identifying the occurrence and distribution of these contaminants.

Index of Subjects

Specific studies on PCB contamination of the Great Lakes are being conducted by the USGS. For example, the USGS, in cooperation with the Wisconsin Department of Natural Resources, is estimating the total mass of PCB's present in the bottom sediments of the lower Fox River and computing the PCB load carried by the river to Green Bay in Lake Michigan. Accumulation of PCB's and other organochlorine pesticides in fish from Lake Michigan has resulted in fish-consumption advisories being issued by Wisconsin, Michigan, Illinois, and Indiana.

Additionally, the USGS, in cooperation with the Michigan and the Wisconsin Departments of Natural Resources, the Indiana Department of Environmental Management, and the U.S. Environmental Protection Agency, is estimating the total mass balance of pollutants entering the ecosystem of Lake Michigan. Under the program, which was designed by the USGS, scientists are currently (1995) monitoring 11 tributaries that make up 50 percent of the drainage area of Lake Michigan and are assumed to contribute more than 90 percent of the tributary load of PCB's. Each of these tributaries, which carry drainage from four States, has complex flow and transport conditions near its mouth. Acoustic flow meters, data loggers, automatic water-quality samplers, and telecommunications equipment are required to obtain the necessary data from these sites. These data will be used along with

atmospheric and open-lake data to develop a mass-balance model for Lake Michigan that will be used to evaluate management options to reduce chemical concentrations and thus shorten the time that fish-consumption advisories will be needed.

Combined sewer overflows (CSO's) constitute another serious environmental concern to the Great Lakes. CSO's are structural devices on combined sewer systems that divert untreated sewage mixed with stormwater to tributary rivers or directly into the Great Lakes. In ongoing projects in Cleveland, Detroit, Houghton, Marquette, and Sault Ste. Marie, USGS scientists are measuring discharge, nutrients, metals, polyaromatic hydrocarbons, and eight organic bioaccumulative substances identified by a binational program. These investigations will characterize storm-related water quantity and quality from selected CSO's, thus allowing the USGS to make better estimates of annual pollutant loads from CSO's to the Great Lakes.

Selected Great Lakes Monitoring Information

Since the turn of the century, the USGS has maintained and operated a monitoring network of surface-water-gaging stations on streams and rivers draining to the Great Lakes (fig. 2). Data from this multistate monitoring network provide the USGS and its many cooperators with information on surface-water flows, quantity of available water, and water-quality characteristics. These data are critical for long-term management and daily administration of water resources.

Long-term data from the USGS stream-gaging network are used by Federal, State, and local agencies to design bridges and culverts that will convey peak flows and for flood-plain mapping to minimize flood damages. The National Weather Service and operators of hydroelectric power utilities and wastewater-treatment plants use stream-gaging data on a daily basis. Managers of fisheries and wildlife sanctuaries use USGS stream-gaging data during periods critical to the maintenance of suitable habitats for the fauna and flora they manage.

The USGS currently (1995) has two National Water-Quality Assessment (NAWQA) Program studies underway in the Great Lakes area—the Western Lake Michigan Drainages and the Lake Erie–Lake St. Clair Basin. The long-term goals of the NAWQA Program are to describe the status and trends in the quality of a large representative part of the Nation's surface- and ground-water resources and to identify the natural and human factors that affect their quality. In particular, the USGS is measuring concentrations in surface and ground waters of pesticides used in agricultural and urban areas to determine their distribution and frequency of occurrence. The presence and distribution of nutrients (nitrogen and phosphorous) also are being studied to determine if the major sources of these are agricultural practices, discharges from sewage-treatment plants, or combined-sewer overflows. The NAWQA Program will produce water-quality information that will be useful to policymakers and water managers at the local, State, and national levels of government.

Figure 2. Surface-water-gaging stations on streams and lakes draining to the Great Lakes.

Diversions of Water

Joint ownership of the Great Lakes by the United States and Canada has necessitated regulation of the diversion and use of water from the Lakes. Historically, the State of Illinois has diverted water down the Illinois River (by means of the Chicago River and associated waterways) to carry sanitary sewage away from Lake Michigan and to allow barge traffic on the Illinois River between the Mississippi River and Chicago. The U.S. Supreme Court decree (December 1, 1980) regulating the diversion and use of water from Lake Michigan limits diversion and use in Illinois to a 40-year average of 3,200 cubic feet per second. Accurate accounting of the water diversion is necessary to ensure compliance with the Court's decree.

The USGS is cooperating with the U.S. Army Corps of Engineers, the Illinois Department of Transportation–Division of Water Resources, and the Metropolitan Reclamation District of Greater Chicago to increase the accuracy of Lake Michigan diversion accounting. The USGS is using state-of-the-art techniques and technology, such as doppler acoustic flow profilers, acoustic velocity meters, and dye dilution to measure flow accurately in the Chicago River and the Chicago Sanitary and Ship Canal, as well as to monitor leakage through the lakefront diversion-control structures. Through this new technology, previous estimated values of leakage through the diversion-control structures were found to be too low, and the water-budget accounting was adjusted accordingly.

Fluctuating Water Levels—Coastal Erosion and Submergence

As the result of fluctuating water levels in the Great Lakes, hundreds of mil-

lions of dollars have been lost by the millions of people and many industries located near their shores. Record high water levels in the Great Lakes from 1985 through 1987 resulted from above-average rainfall. During this period, stormwaves superimposed on high water levels caused extensive and costly damage to the Illinois shore, particularly Chicago lakefront business, recreation beaches, parks, and private homes. The shore along western Lake Erie eroded rapidly, resulting in damage to public and private property. On steep shorelines with easily eroded soils, such as the unstable clay bluffs along parts of Lake Superior in northwestern Wisconsin, waves undercut the bluffs and caused them to slump. In these areas, the shore eroded as much as 15 to 20 feet in 1 day. Landslides along a 15-mile stretch of coastal bluffs on Lake Michigan north of Chicago resulted in erosion and retreat of the bluffs that averaged more than 9 inches per year and locally exceeded 3 feet per year.

The USGS, in cooperation with the Illinois State Geological Survey, the Indiana Geological Survey, and many universities, recently completed a coastal study of southern Lake Michigan in response to disastrous flooding in Chicago. The 5-year study documented the timing and magnitude of prehistoric lake-level fluctuations and assessed some of the important geologic processes responsible for severe erosion of the Illinois–Indiana shore. Seismic reflection data were collected to determine thickness and distribution of rock and sediments. These data, coupled with bathymetric data, were used to prepare a physiography map of the lake bottom. Maps of the areal distribution of bottom-sediment types also were prepared by using side-scan sonar, sample data, and observations by scuba divers. Sonar data also aided in assessment of the condition and extent of damage to shore-protection revetments along the Chicago waterfront. Profiles of sand thicknesses on beaches and the lake bottom based on 700 sample locations along 50 transects off the Illinois–Indiana shore resulted in the most complete characterization yet of sand distribution. Such information can be used to identify offshore sand for replacement of eroded beaches.

The USGS, in cooperation with the Ohio Department of Natural Resources, is documenting the historical erosion of Ohio's shoreline bluffs to determine the effects of natural processes and human activities on shore erosion. Understanding sand movement by mapping lake-bottom physiography and sediment distribution could save millions of dollars in beach replenishment and maintenance costs. The results of this study of erosion potential will have wide applications because the Ohio shore is similar to other eroding areas throughout the Great Lakes area.

Scientists from the USGS and various universities are studying long-term water-level fluctuations of the Great Lakes (fig. 3). Observed water levels along the southern shore of Lake Michigan varied 5.2 feet between low levels in 1964 and high levels from 1985 through 1987. However, recent USGS studies have shown that water levels along the southern shore varied by as much as 8.4 feet during the past 160 years. This new information on lake-level fluctuations provides planners with a long-term historical framework to use in protecting and managing lakeshore resources.

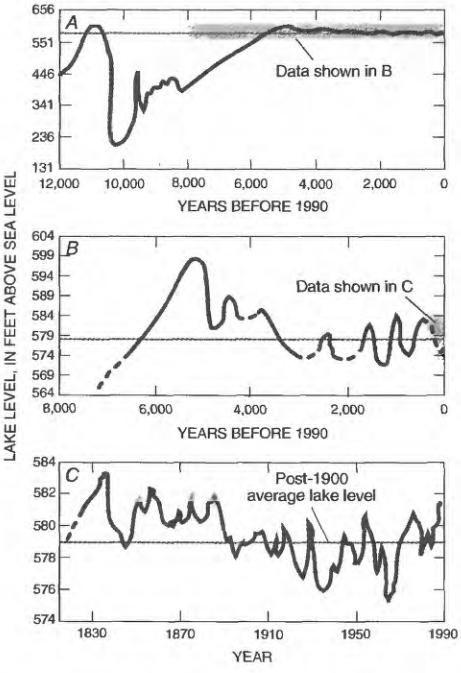

Figure 3. Scales of lake-level change in the past. *A,* In the past 12,000 years, the lake has experienced dramatic change due to changing outlets and ground tilting; *B,* For the past 5,000 years, climatically controlled fluctuations have been superimposed on a general falling trend; *C,* During the past 160 years, lake level has fluctuated a total of about 8 feet. Each peak in this century has been higher than the preceding peak.

At Bay Mills, Michigan, on the southern shore of Lake Superior a few miles west of Sault Ste. Marie, the USGS, in cooperation with the University of Michigan, is studying sediment core samples for their historical lake-level record. Submerged sand spits, which formed at Bay Mills during the past 2,000 years, indicate periods of extended low lake levels with mean levels that are 5 feet lower than the current mean level. Natural climatic changes during that time lowered Lake Superior for extended periods, perhaps centuries.

USGS scientists, in cooperation with the National Park Service and the University of Wisconsin, have documented approximately 15 feet of submergence over the past 2,000 years at the Apostle Islands National Lakeshore near Bayfield, Wisconsin. Studies have shown that the Lake Superior Basin is being progressively tilted from the northeast to the southwest as a result of residual uplift following glacier retreat about 10,000 years ago. Lake level is controlled by the spillway to the St. Marys River at Sault Ste. Marie, but the outlet is rising more rapidly than most other points along the U.S. shore of the lake. As the outlet rises, the accompanying lake level submerges the shore at an increasing rate westward from Sault Ste. Marie to Duluth, Minnesota. Wetlands and forests are submerged below the present lake level. At Duluth, as much as 18 feet of submergence has taken place. The rates of lake-level rise in these areas are on the order of 1 inch per decade. Rising lake level attributable to uplift at the outlet will continue to inundate low-lying areas and river mouths, to expand wetlands, and to contribute to erosion of exposed and erodible shores. Engineering projects along shore and river mouth areas need to take such changes into account.

Coastal Wetlands

Coastal wetlands of Lakes Superior, Michigan, Huron, Erie, and Ontario protect the drinking water and shoreline communities of millions of Great Lakes residents. Coastal wetlands are an ecologically important but disappearing compo-

nent of the Great Lakes (fig. 4). These wetlands provide habitat for many species of plants and animals.

The USGS, in cooperation with numerous State Departments of Natural Resources, Native American Tribes, State universities, and other Federal agencies, is collecting and analyzing sediment cores to document the history of wetland changes in the Great Lake States. The analysis is delineating the high levels of the lakes, the timing of peat deposition, the changing climatic regimes, the extent of former wetlands, the deterioration and regrowth of wetlands, and the history of early human impacts on the wetlands. Results of the analyses are being incorporated into digital mapping products that will provide land-use planners, policymakers, and scientists with a predictive tool that can be used to manage and protect wetlands. Such information will help water managers identify locations where wetland preservation and restoration can strike the best balance between ecological and economic imperatives.

Many processes have been interacting to cause the deterioration of Great Lakes wetlands since the glaciers melted. Fish and migratory bird populations are being adversely affected by a loss of food and habitat as a result of increased sediment loads in the water and shallowing of the aquatic habitats. The U.S. Environmental Protection Agency has sought USGS assistance to develop methods to estimate the contribution of sediment loads of several large rivers to the Great Lakes in areas of Illinois, Indiana, Michigan, Minnesota, and Wisconsin. Models are being developed to estimate the sediment loads of smaller streams that yield sediment to the Great Lakes.

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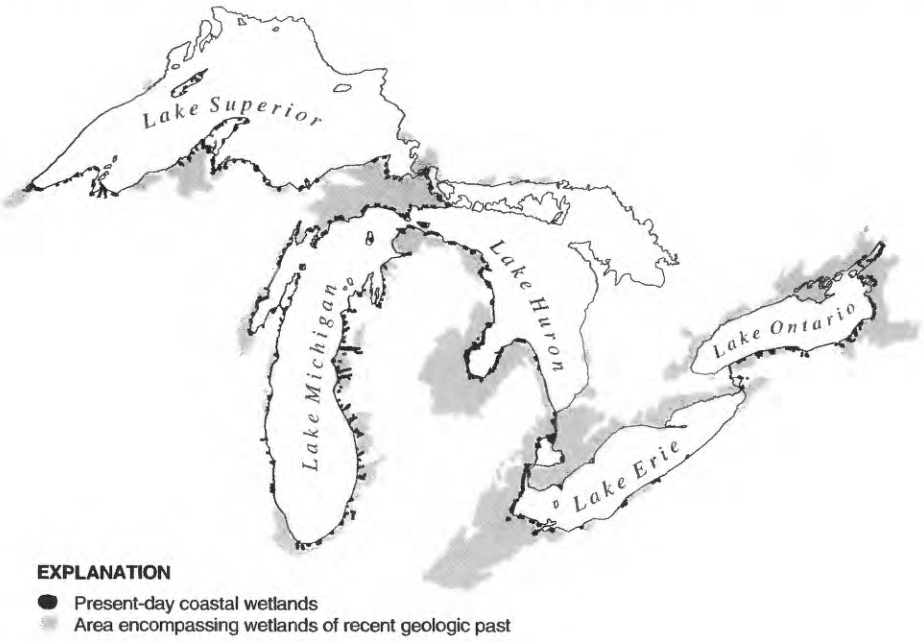

Figure 4. Great Lakes coastal wetlands.

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Additional earth science information can be found by accessing the USGS "Home Page" on the World Wide Web at "http://www.usgs.gov," or by calling 1-800-H2O-9000 (1-800-426-9000)

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