WATER POLLUTION PROBLEMS OF LAKE MICHIGAN AND TRIBUTARIES

ACTION FOR CLEAN WATER

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JANUARY 1968

U. S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
GREAT LAKES REGION

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I-INTRODUCTION

On the basis of a request from Governor Otto Kerner of Illinois, dated November 22, 1967, and on the basis of reports, surveys or studies, and in accordance with Section 10 of the Federal Water Pollution Control Act (33 USC 466 et seq.), Secretary of the Interior Stewart L. Udall called a conference in the matter of pollution of the waters of Lake Michigan and its tributary basin (Illinois-Indiana-Michigan-Wisconsin). The area covered by the conference is shown on Figure 1.

The conference is to convene at Chicago, Illinois on January 31, 1968; conferees will be representatives of the Federal Government and the four States involved.

This report and its supporting documents were prepared for the information of the conferees and other interested parties, and for use by the conferees in their consideration of actions needed to improve and preserve the quality of waters in the conference area. The report is based on studies and investigations by the Federal Water Pollution Control Administration, paralleling investigations made through cooperative agreements by other agencies of the Department of the Interior, and information obtained from other Federal agencies, agencies of the four Lake Michigan States, municipalities, universities, and others.

The contributions of all who provided assistance and information are gratefully acknowledged.

LAKE MICHIGAN BASIN

FIGURE 1

II-DESCRIPTION OF THE BASIN

POPULATION

Large concentrations of industry and people, as well as considerable agricultural activity, characterize the Lake Michigan watershed. In 1960, approximately 5.5 million people lived within its boundaries. (1)* Millions more live in nearby areas, including almost seven million in the Chicago Metropolitan Area. (2) The population of the watershed has doubled within the past fifty years and is likely to double again during the next fifty. (3)

Nearly all the population within the watershed is accounted for by the States of Wisconsin, Michigan, and Indiana, which had watershed populations of 2.2 million, 2.2 million and 970,000, respectively, in 1960. Although a large part of the seven million people in the Chicago Metropolitan Area use Lake Michigan for water supply and other purposes, the population within the watershed in Illinois was only 140,000.

The population around Lake Michigan has doubled in the past fifty years. Here, bathers enjoy the surf at a public beach at Grand Haven, Michigan.

*Numbers in parentheses refer to references listed at end of report.

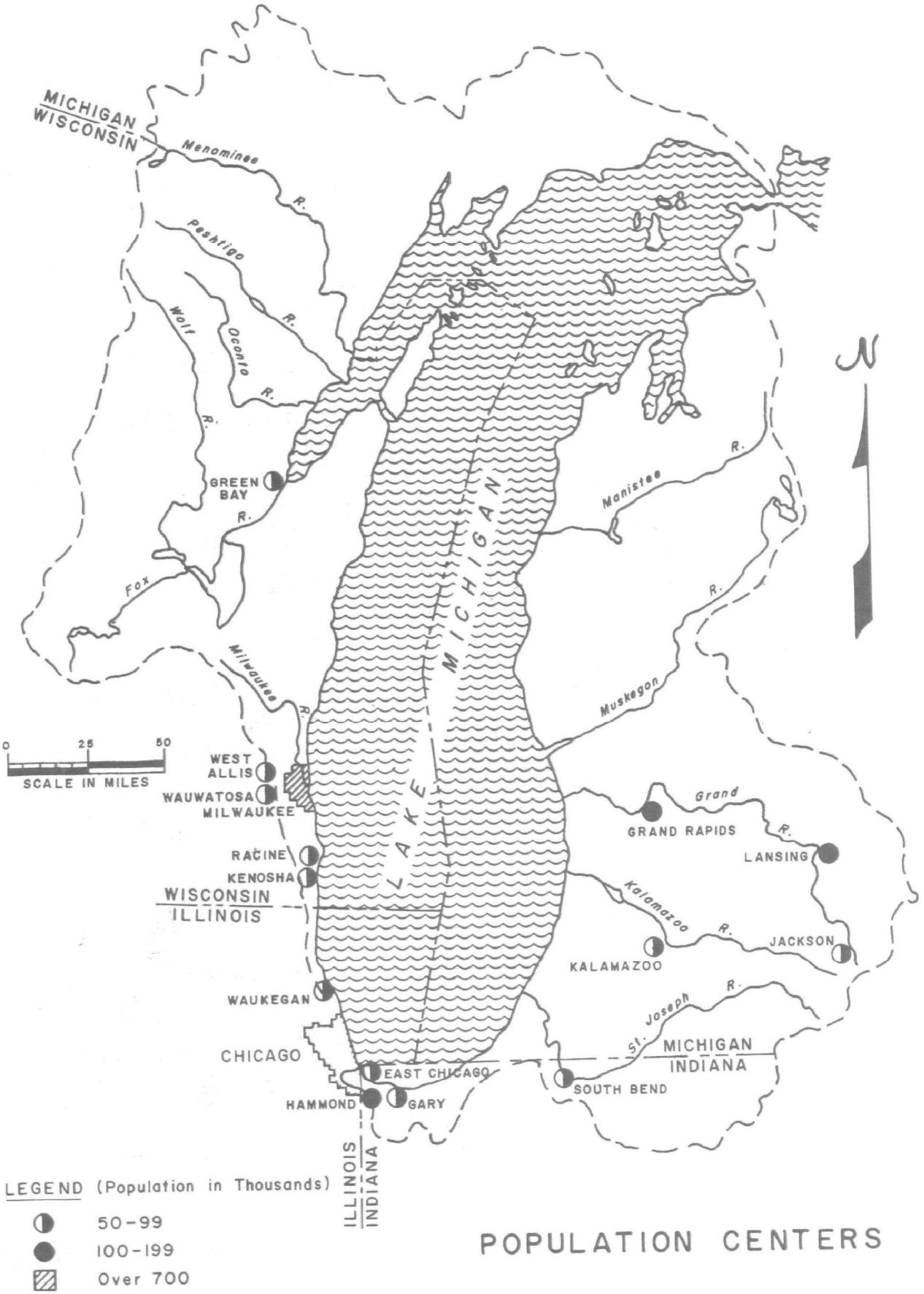
The major metropolitan areas lying entirely or substantially within the watershed are: Milwaukee, Wisconsin; Gary-Hammond-East Chicago, Indiana; and Lansing, Michigan, which had populations of approximately 1.2 million, 0.6 million, and 0.3 million, respectively, in 1960. (See Figure 2) Whereas the population of the watershed increased 22 percent between 1950 and 1960, the population of the ten metropolitan areas increased 27 percent during the same period. The Gary-Hammond-East Chicago area had the most rapid rate of growth, increasing by 40 percent. Present signs indicate that the metropolitan areas will continue to demonstrate large increases in population, although some smaller areas have had and are likely to continue to have rapid growth rates.

INDUSTRY

Industrial activity in the watershed is both substantial and diversified. Figure 3 shows the principal centers of industrial activity. In 1963, value added by manufacturing activity totaled almost 10 billion dollars; manufacturing employed 834,000 people. (4) The Nation's industrial activity is expected to increase almost sixfold by the year 2020. For the most part, the Lake Michigan watershed will share in this increase although different areas and industries will have varying growth rates. The industrial distribution pattern varies, with Wisconsin having its largest concentration in the Milwaukee area, in addition to substantial activity in the Racine and Kenosha areas. Michigan's industrial activity is located primarily in the five metropolitan areas of Grand Rapids, Kalamazoo, Muskegon, Jackson and Lansing. The Gary-Hammond-East Chicago area accounts for the major part of Indiana's industrial activity in the watershed. There are major steel and chemical industries in the Calumet area in Illinois.

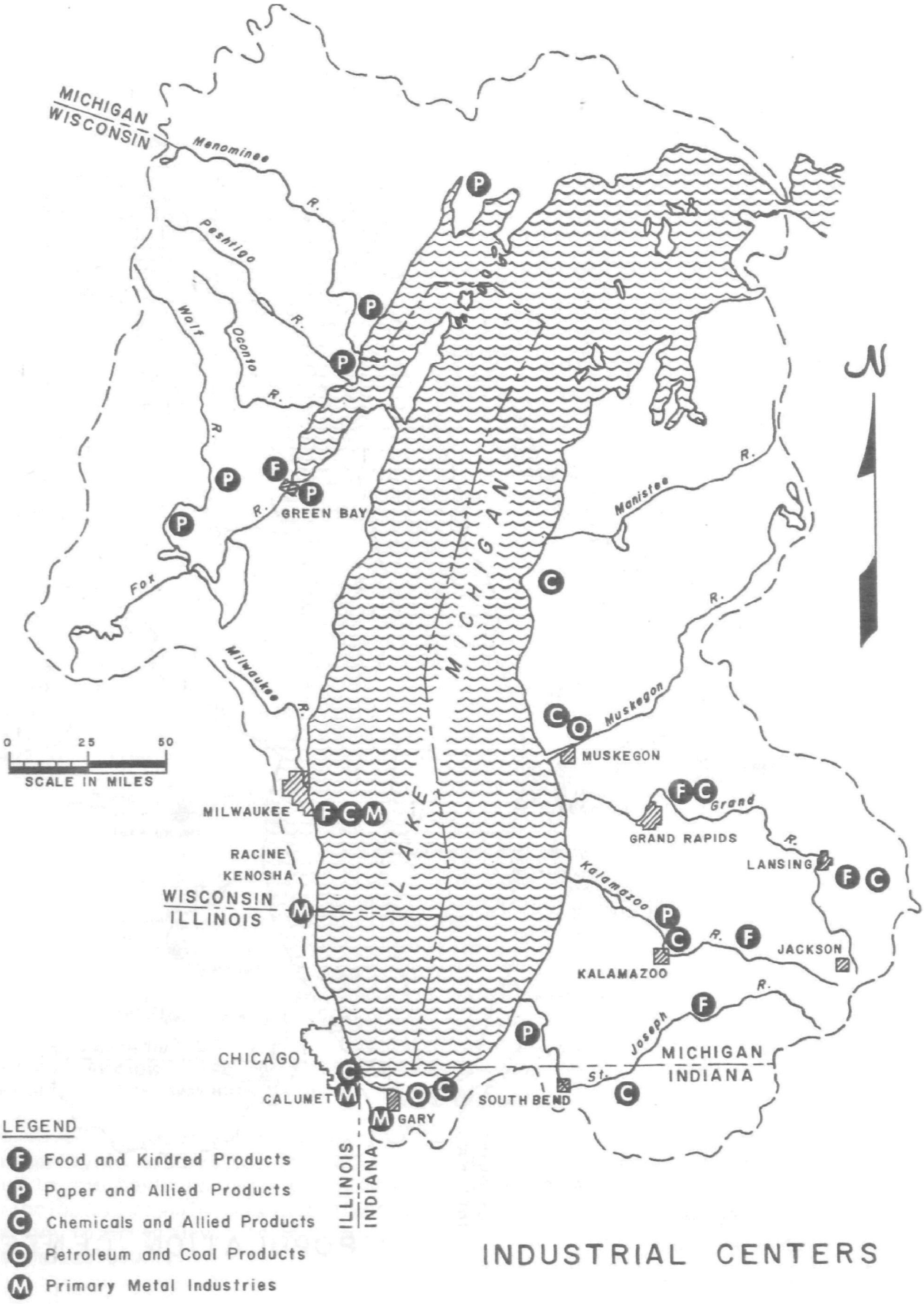
The industrial mix also differs considerably from area to area. Many of the industries are those requiring large quantities of water and producing substantial wastes, such as food and beverages, chemicals, paper products and primary metals. Growth of these industries is expected to be substantial and to approximate national growth rates. Food and Kindred Products and Primary Metal Industries are important in the Milwaukee area; Primary Metal Industries, Chemical Products, Petroleum Refining, and Fabricated Metal Products predominate in the Gary-Hammond-East Chicago area, with the Primary Metals Industry accounting for about two-thirds of the area's value added by manufactures. This industry has expanded greatly in the area in recent years. New facilities provide modern production techniques. In 1963, the Gary-Hammond-East Chicago area accounted for 11.5 percent of the Nation's total of steel rolling and finishing.

Pulp, paper and paperboard mills are numerous in the watershed, primarily in Wisconsin. In 1963, Wisconsin counties wholly or partially within the basin had 21 such plants employing over 100 persons in each. Principal Wisconsin concentrations are along the Fox River and other tributaries to Green Bay. In Michigan, the principal concentration is in Kalamazoo County.



POPULATION CENTERS

FIGURE 2



INDUSTRIAL CENTERS

FIGURE 3

The value of farm products accounted for by counties of the Lake Michigan watershed totaled over 900 million dollars in 1964. In that year, there were approximately 2.4 million cattle and calves on watershed farms of which 1.4 million were in Wisconsin counties. The production of crops, including fruits, is also substantial. In 1964, over a half million tons of fertilizers were used in their production. (5)

COMMERCIAL SHIPPING

The Great Lakes, with their connecting channels and the Welland Canal, form a deep-draft navigation chain with a controlling depth of 27 feet, extending from the west end of Lake Superior to the south end of Lake Michigan and to the east end of Lake Ontario at the head of the St. Lawrence River. There is a 9-foot barge canal connection between the deep draft Calumet Harbor and River project at the southerly end of Lake Michigan and the 9-foot Illinois Waterway, which connects with the Mississippi River inland waterway system.

During the 10-year period 1955-1964 annual commerce on the Great Lakes averaged 190 million tons. During this period, traffic in four major commodities, iron ore, coal, stone and grain, comprised about 85 percent of total United States commerce on the Great Lakes. Commerce at 27 Federal Harbors on Lake Michigan, excluding internal, intraport and local traffic, totaled 70 million tons in 1964; Calumet Harbor (Illinois) accounted for approximately 24 million tons, and Indiana Harbor, 18 million tons. Commerce at 15 private Lake Michigan Harbors totaled 29 million tons, including 9 million tons at Gary.

A large percentage of total shipments of petroleum products on the Great Lakes is from Indiana Harbor, Indiana - there are also substantial shipments from Muskegon, Michigan. (6)

WATER RESOURCES

The total drainage area for the Lake Michigan basin is 67,900 square miles. Of this, 22,400 square miles are the lake proper. Sixty-four percent of the remaining land area is in the State of Michigan, 31 percent is in Wisconsin, 5 percent is in Indiana, and 0.2 percent is in the State of Illinois. (7) The Illinois portion does not include the area formerly in the Lake Michigan watershed, whose drainage has been diverted to the Illinois watershed for pollution control.

The topography and soils of the Lake Michigan basin have been formed by several glaciations. The southern portion of the basin is generally rolling with glacial moraines being the only prominent hill areas. The northern portion exhibits more rugged terrain with frequent rock outcrops which cause higher gradients on the streams, and more inland lakes, typical of ground moraine areas. There are over 8,100 lakes in the basin, with combined surface area of 680,000 acres. (7)

Lake Michigan itself occupies a great valley in Paleozoic sedimentary rocks at the edge of the preCambrian Canadian shield. This valley originated in preglacial times in rock subject to erosion. The lake exerted a strong influence on glacial ice movements which were responsible for the final shaping of the land area. The maximum depth of the lake, 923 feet, occurs in the northern portion; the average depth is 276 feet. The volume is 1,170 cubic miles, or 3.9 billion acre feet. The average outflow of the lake through the Straits of Mackinac is estimated to be 48,000 cubic feet per second. The straits are of sufficient size that there is no measurable loss in elevation, so Lake Michigan and Lake Huron are at the same elevation, which has varied from 583.7 feet to 577.1 feet. (8) An additional 3,100 cubic feet per second are diverted from the lake at Chicago for municipal water supply and pollution control. This total outflow of 37,000,000 acre feet per year is about one percent of the volume of water in the lake.

Boat marinas dot the shores of Lake Michigan.
These ships are anchored at Michigan City, Indiana.

Most of the major streams (See Table I), start with relatively steeper gradients at the headwaters and decrease as they approach Lake Michigan. Harbors have been developed at the mouths of most of these rivers. The 20 major streams drain 36,400 square miles or 80 percent of the total land area. Of this, 31,940 square miles or 70 percent of the area is gaged. The discharge from this gaged area is 25,500 cfs. These records are totaled without adjustment for nonconcurrent periods and are summed only to show relative magnitude to the estimated outflow of 51,000 cubic feet per second.

The average precipitation over the basin ranges from 26 to 34 inches, and 60 percent occurs during the growing season, May through September. This supports the agricultural economy, and irrigation is of minor significance.

The total shoreline of Lake Michigan is 1,660 miles; about 1,300 miles of this is suitable for recreation. Only 80 miles have been developed as public recreation areas. (7) Unfortunately, the areas that are closest to the large concentrations of population are also subject to the highest pollution level.

The groundwater resources of Lake Michigan basin have not been studied as intensively as the surface waters. This is due in part to the general adequacy of the groundwater for domestic, municipal and industrial water use. The northern portion of the basin, with relatively little sedimentary rock, must rely on groundwater from the glacial material. The southern portion of the basin can obtain substantial quantities of water from the sedimentary rocks. The quality of this water is generally adequate for all purposes. However, in the past few years, increased industrialization and urbanization has resulted in scattered shortage areas. The city of Green Bay, Wisconsin, is one example where the groundwater was not adequate, as evidenced by rapidly declining watertables (local surface waters were unsatisfactory in quality) so Lake Michigan was relied on for the municipal water supply. The cities in the Grand River Basin are initiating studies to determine feasibility of obtaining surface waters from Lake Michigan to augment existing groundwater supply. Most of the large municipalities which lie on the lake shore use Lake Michigan for municipal water supply; the groundwater sources have not been thoroughly exploited.

LAKE CURRENTS

Knowledge of lake currents is fundamental to an understanding of the fate of pollutants put into the lake and the effects, both local and widespread, of these pollutants on water quality and associated water uses. To fill the need for this information the Federal Water Pollution Control Administration conducted a study of speed and direction of currents, and water temperatures, throughout Lake Michigan. Field instrumentation and observation were made during 1962-64; after analysis of the great mass of data obtained from the study, a report of the findings was published recently. (9)

TABLE 1

MAJOR TRIBUTARIES TO LAKE MICHIGAN*

NAME OF RIVER	TOTAL DRAINAGE AREA sq.mi.	GAGED DRAINAGE AREA sq.mi.	MEAN DISCHARGE cfs	PERIOD OF RECORD
Milwaukee	845	686	381	1914-65
Sheboygan	440	432	232	1916-24, 50-65
Manitowoc	442	0	--	--
Fox	6,443	6,150	4,140	1896-1965
Oconto	933	678	569	1906-08, 13-65
Peshtigo	1,155	1,124	832	1953-65
Menominee	4,150	3,790	3,098	1907-08, 13-65
Ford	468	450	324	1954-65
Escanaba	920	870	895	1903-12, 50-65
Whitefish	315	0	--	--
Manistique	1,450	1,402**	1,699	1938-65
Boardman	347	223	186	1952-65
Manistee	2,010	1,980***	2,095	1951-65
Pere Marquette	772	709	608	1939-65
White	480	380	367	1957-65
Muskegon	2,780	2,350	1,889	1909-14, 16-19, 30-65
Grand	5,572	4,900	3,362	1901-05, 06-18, 30-65
Kalamazoo	2,030	1,600	1,296	1929-36, 37-65
St. Joseph	4,590	4,056****	3,398	1930-65, 51-65
Burns Ditch	280	160	130	1943-50, 55-65
Total	36,422	31,940	25,501	

* Clockwise from Milwaukee
** Total of Indian and Manistique Rivers above confluence
*** Total of Manistee and Little Manistee Rivers above confluence
**** Total of St. Joseph and Paw Paw Rivers above confluence

Data Source: 1965 Surface Water Records of Indiana, Michigan and Wisconsin, U.S.G.S.

Although the outflow rate from Lake Michigan is comparable to the flow in the Mississippi River at Rock Island, Illinois, the lake itself is so large in comparison that this outpouring of water produces an almost imperceptible movement of water within the lake. But the lake water is not standing still; it is kept in constant motion principally by the wind, which not only generates the visible surface waves but stirs and mixes the water throughout the lake. In fact, a combination of wind force and seasonal density changes brings about vertical exchange of waters even, at times, extending to the bottom of the lake's deepest hole -- some 920 feet.

Both water movements and rate of mixing are materially influenced by the formation of thermoclines, or zones of temperature transition between two layers of water which differ in temperature and density. Once stabilized at depths which prevent storm turbulence interruption, the thermocline effectively prevents mixing of waters in the epilimnion (upper stratum) with those in the hypolimnion (lower stratum). This stratification is especially characteristic of Lake Michigan in the summer. A weak stratification, involving very small density differences, sometimes occurs in winter. The summer thermocline begins to form in late spring at a depth of a few feet, and progressively recedes to greater depths, probably reaching a depth of about 200 feet by early fall. With the onset of winter, the thermocline disappears, stratification breaks up, and water mixing occurs throughout the full depth of the lake.

Thermal bars, phenomena resulting from a difference in temperature between adjacent waters along a vertical plane, occur both in the spring and in the fall in shallow waters, parallel to the shoreline. Like the thermocline, a thermal bar inhibits mixing between the shallow waters along the shore and the deeper lake waters.

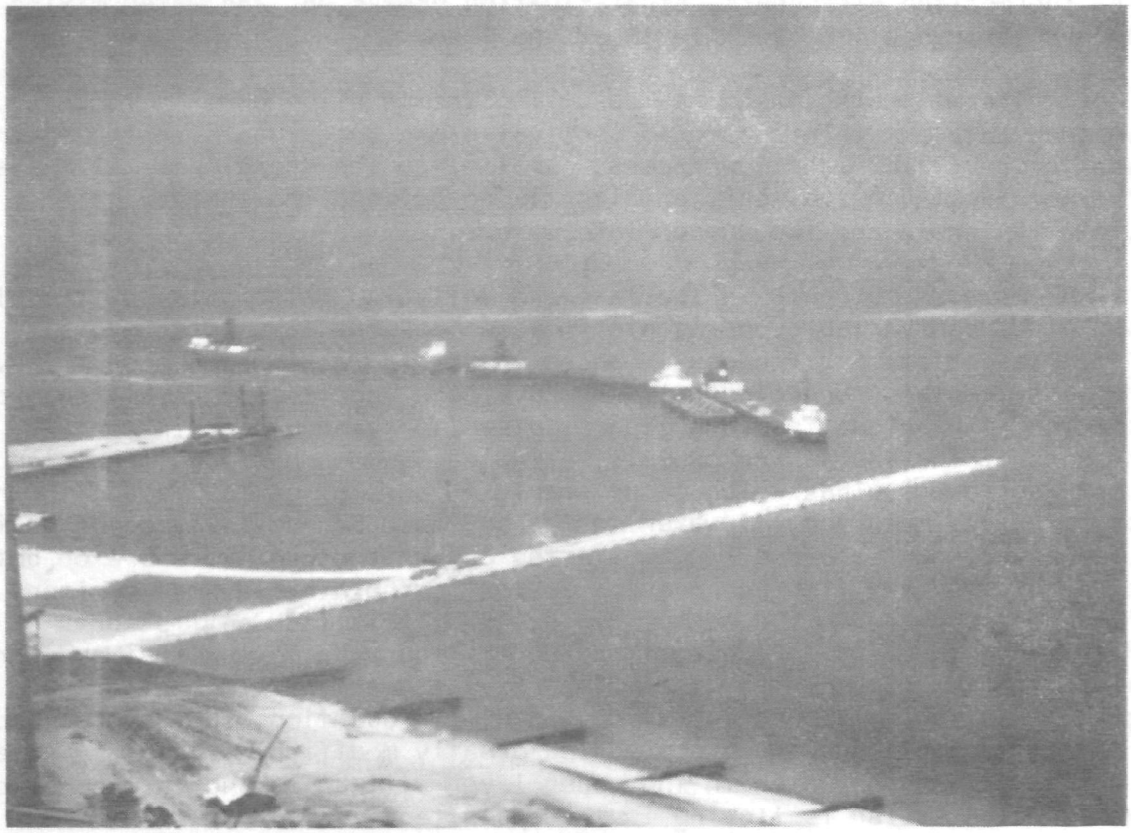
Because currents in the lake are motivated principally by the wind, and winds are variable, horizontal movement of the lake water exhibits an infinite variety and frequent changes in both direction and speed. Nevertheless, certain recurring patterns have been identified, resulting from the fact that winds from one general direction predominate in certain seasons of the year. For example, a typical summer pattern is created by south-southwest winds which occur nearly 40 percent of the year. In this pattern, the main body of water in the southern basin slowly revolves in a counterclockwise direction, while the currents closer to shore on both sides of the lake flow northward. In the northern basin, the dominant flow is southward in the center of the lake; this flow splits north of Milwaukee, one part moving east and north, the othermoving west and north, along the two shores. At other times of the year and under other wind regimes this whole pattern can be reversed. In addition, the generalized circulation patterns are obscured and greatly modified by internal waves, and frequently the water in the upper layer will be moving in one direction while deeper water is flowing in the opposite direction.

If the complex patterns of motion in Lake Michigan water were to be described in the shortest possible expression, it would be "restless waters." There are, paradoxically, two extreme cases relevant to water pollution

which can and do exist. At the one extreme, pollution-laden waters put into the lake at a point can remain in the immediate vicinity in concentrated form for days on end, moving slowly and virtually en masse. On the other hand, any persistent dissolved constituents put into the lake are certain to become mixed with and to affect the quality of water through the whole lake, in a time span of months or years.

WATER USES

The data on water use can be subdivided into several categories, the first being municipal water use which includes all water processed by municipalities even if utilized in industrial processes. Fifty municipalities treat an average of 1.47 billion gallons of Lake Michigan water daily; of this, over one billion gallons per day are utilized by the City of Chicago and suburbs. The cities in the State of Wisconsin use approximately 240 million gallons daily (mgd), Indiana and Michigan each use 80 mgd. (10) Utilization of water from surface sources other than Lake Michigan is minimal, except for 18 mgd from Lake Winnebago used by four cities in that vicinity. (11) The remaining cities in the basin rely on ground water for their municipal supplies.



Industries use an estimated 4.25 billion gallons of Lake Michigan water daily. The scene above shows Bethlehem Steel Company expanding its new plant facilities at Burns Harbor, Ind., into the lake.

The demand for municipal waters from Lake Michigan is anticipated to increase threefold by the year 2020, although the growth of population will be less. This is due to increased per capita usage and to use by municipalities that have difficulty obtaining additional groundwater supplies. The value of Lake Michigan waters for municipal supply is one of the main reasons why the quality of this lake must be protected.

The industrial water use from Lake Michigan is estimated to be 4.25 billion gallons daily. Of this, 3.2 billion is used in the Indiana portion of Lake Michigan. Michigan industries utilize 586 mgd; the Illinois industries utilize 420 mgd. (10) It is anticipated that the demand for industrial water will also increase about threefold by the year 2020, although the gross industrial output may increase as much as sixfold. This will result from increased efficiency and reuse of water in the manufacturing process. The use of industrial water on the tributaries of Lake Michigan is rather minor, when compared to the use from the lake proper. The largest use area is along the Fox River and Lake Winnebago, where pulp and paper industries are the major users.

The use of water for electric power generation is of three types: hydroelectric generation, thermal cooling, and consumptive use in steam generation. In the Lake Michigan basin, there are 110 hydroelectric generating plants with an installed capacity of 318,000 kilowatts, which generate 1,300,000 megawatt hours of energy annually. (12) The Federal Power Commission lists an additional potential for generation of 745,000 megawatt hours; however, these stations are generally considered uneconomical. The pollution effect of hydroelectric generation is minimal. In streams that have become highly nutrified, the ponds behind the power dams may have algal problems, and the waters released from the power plants may be low in dissolved oxygen. Also, the operation of the hydroplants for peaking power may result in minimal discharges during the off-peak hours which can result in fish kills and inadequate dilution of waste discharges.

The hydroelectric generation is minor when compared to a total of 8,500 megawatts of total installed steam generation capacity in Lake Michigan Basin, of which 7,420 megawatts are along the lake shore; and 5,750 megawatts are in the southern basin. (13) Approximately 600 mgd are used for cooling water. Current plans call for the installation of an additional 1,400 megawatts of fossil-fuel steam generating capacity in the Lake Michigan basin by 1972. (14)

There is currently one nuclear generating plant in operation on Lake Michigan, the Big Rock Point nuclear power station near Charlevoix, Michigan; its capacity is 50 megawatts. There are two plants under construction: One of 700 megawatts, near South Haven, Michigan, and one of 497 megawatts near Manitowoc, Wisconsin. There are plans for the additional construction of five plants by 1973, with the total generating capacity of 6,182 megawatts. (15)

There are 1,087 megawatts of steam generation at sites which utilize surface waters other than the lake for cooling. It is anticipated that few additional large plants will be built that utilize stream water; rather, the new plants will be located along the shores of Lake Michigan. There are smaller internal-combustion powered plants in the basin utilized for peaking power; however, these have no impact on water quality.

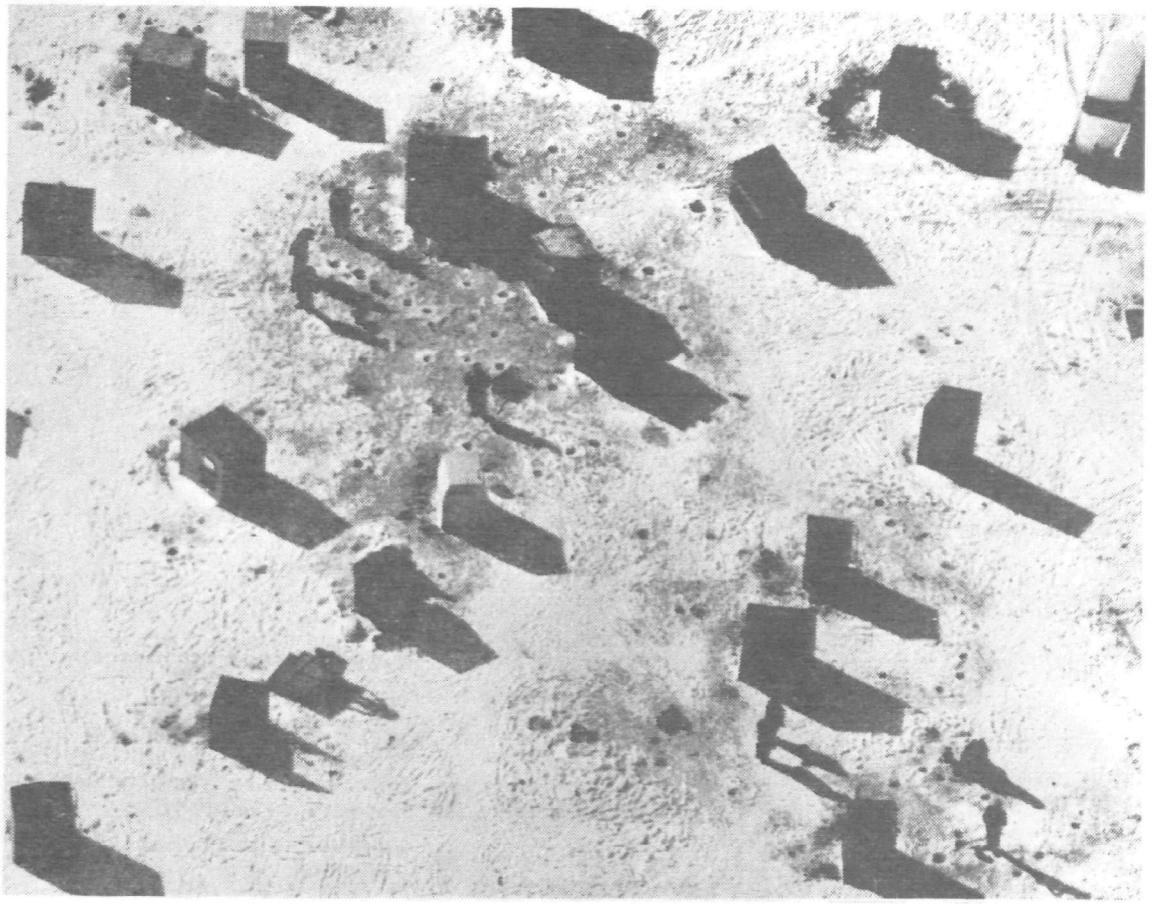
The total generating capacity by the year 1973 could be 17,624 megawatts, which will mean that the reliance on Lake Michigan for cooling purposes will more than double. New technology in electrical transmission systems could cause this figure to be adjusted upward to utilize the available waters of Lake Michigan. The long range demands for cooling water may increase sixfold to parallel expansion in industrial production, but better efficiencies in nuclear plants may reduce this somewhat.

Consumptive use of water in the steam generation process is minor; however, evaporative cooling may be used where waste heat cannot be placed in surface waters. This requires nearly 7,000 gallons per day for one megawatt of capacity and could become a significant consumptive use of water.

The United States Fish and Wildlife Service has prepared a report on the Fish and Wildlife resources of Lake Michigan. (16) The commercial fishing industry has always been a significant part of the economy of the Lake Michigan Basin. Since 1879, the total annual commercial catch has averaged 26.5 million pounds. However, the composition of the catch has changed drastically through the years. Originally, lake trout and herring were the principal catch. The amount of these decreased but a subsequent increase in the number of yellow perch and chubs maintained the same average catch. Recently, carp, smelt and now the alewife have become the major components. However, the value of the catch was 15.6 million dollars in the 1950 period and has declined to only 9.3 million dollars in 1963.

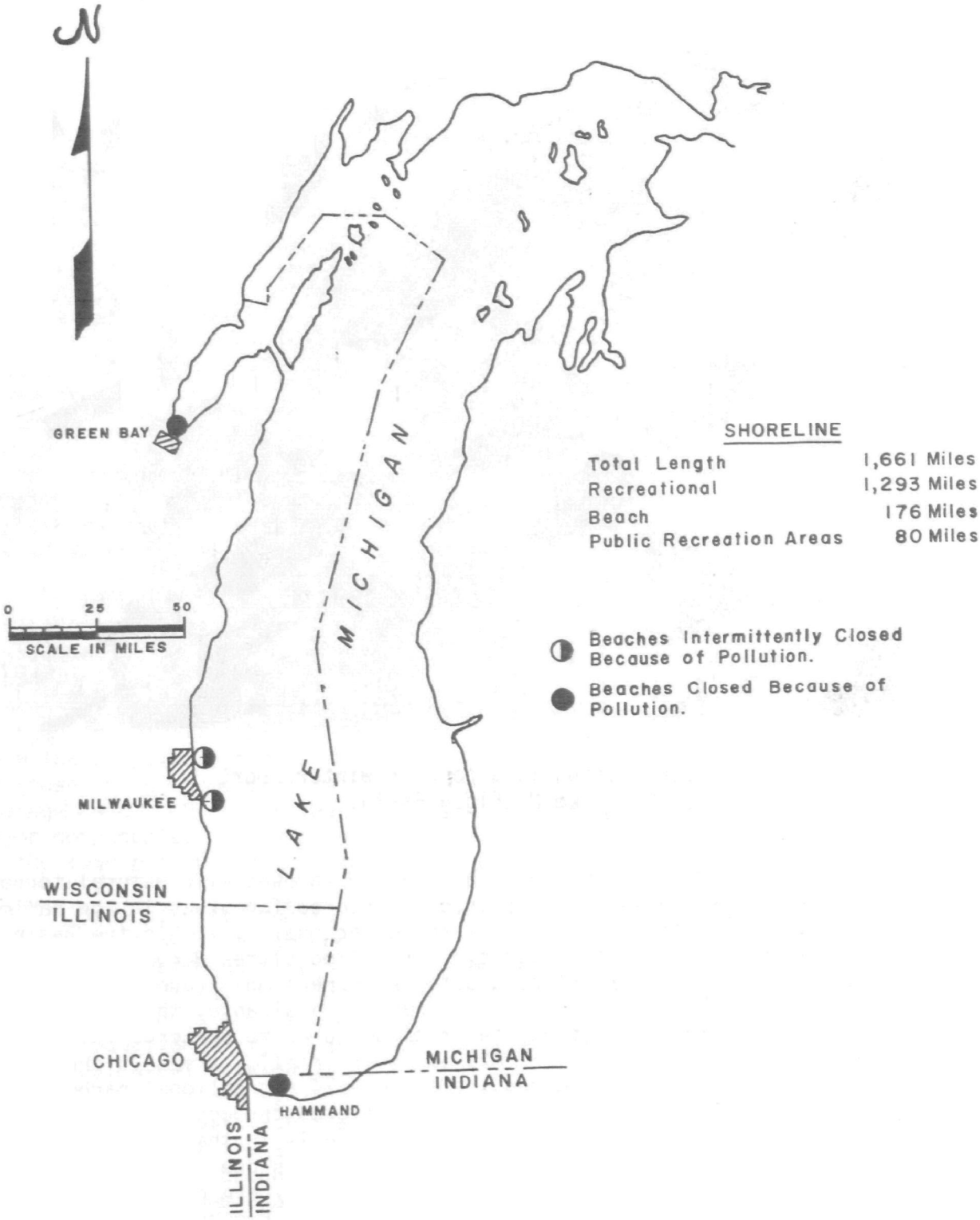
These past fluctuations of commercial fish poundage taken from Lake Michigan have been related more closely to biological and economical factors than to water quality. The sea lamprey which caused a significant decline in the lake trout and whitefish, and now the alewife which has multiplied to an enormous quantity are introduced species. It is hoped that introduction of the coho salmon will aid in restoring the Lake to a proper ecological balance.

However, pollution does have an effect on the fishery of Lake Michigan. Many of the species rely on the tributary streams and shore areas for spawning grounds. The quality of these areas must be maintained to facilitate the natural reproduction of the fish.



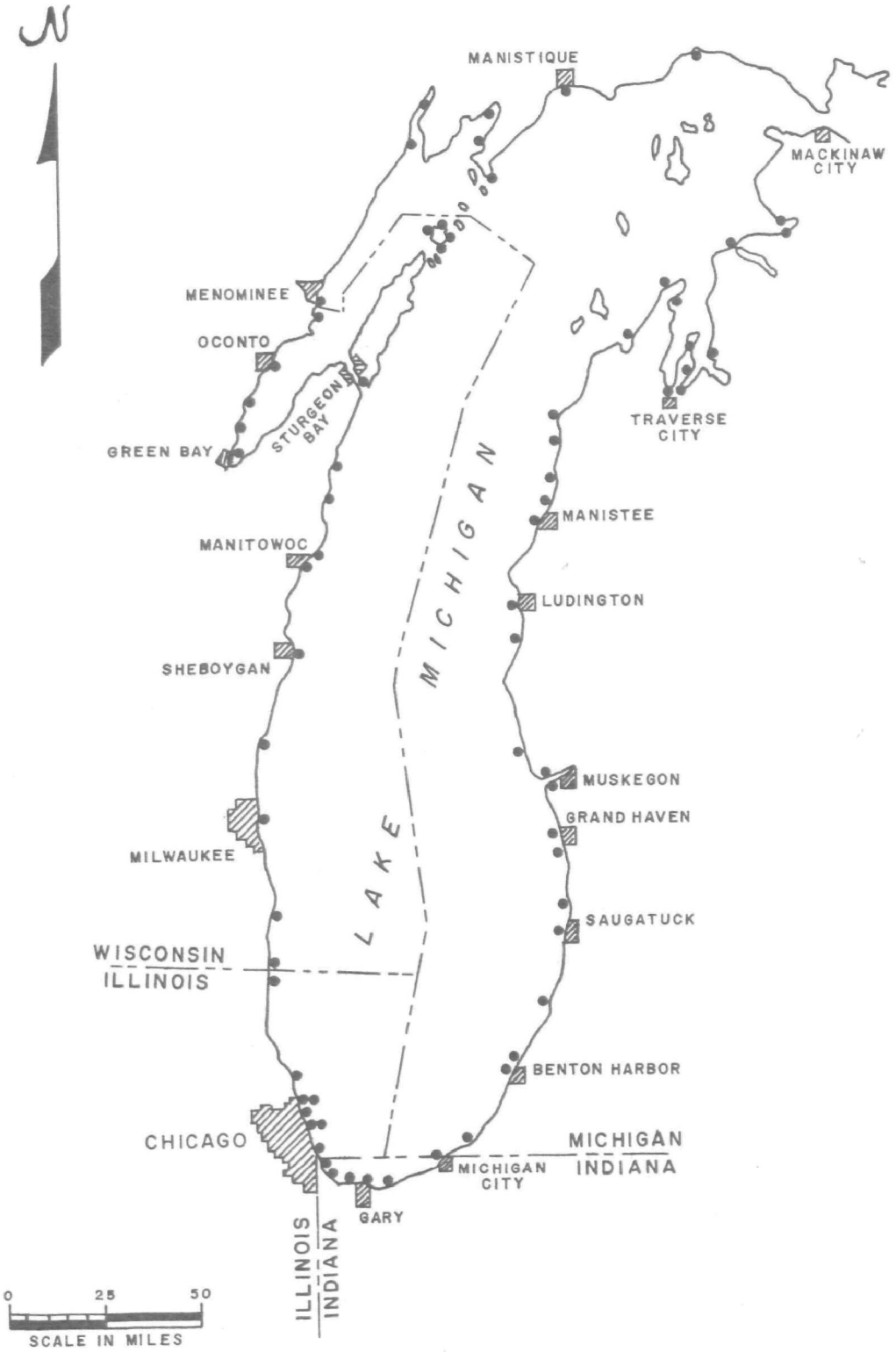
Ice fishing is a popular winter sport in the Lake Michigan Basin.

The Lake Michigan Basin is abundantly endowed with natural terrain making it one of the major water oriented recreation areas in the nation. The preservation and improvement of the water quality within the Basin is imperative to maintain this status. The United States Bureau of Outdoor Recreation report "Water Oriented Outdoor Recreation - Lake Michigan Basin", (7), presents most of the facilities that are available, the problems that are developing, and the action that must be taken to preserve this natural heritage. There are a total of 625 public recreation areas in the Basin. Of these, 536 are water oriented. There are 74 recreational harbors on Lake Michigan. Recreational areas are scattered throughout the Basin, although the major concentration of population is in the southern portion. This, combined with the closing of some facilities due to pollution, has resulted in crowding of the facilities in the southern portion of the Basin. Figure 4 shows Lake Michigan beaches, and Figure 5 shows recreation harbors.



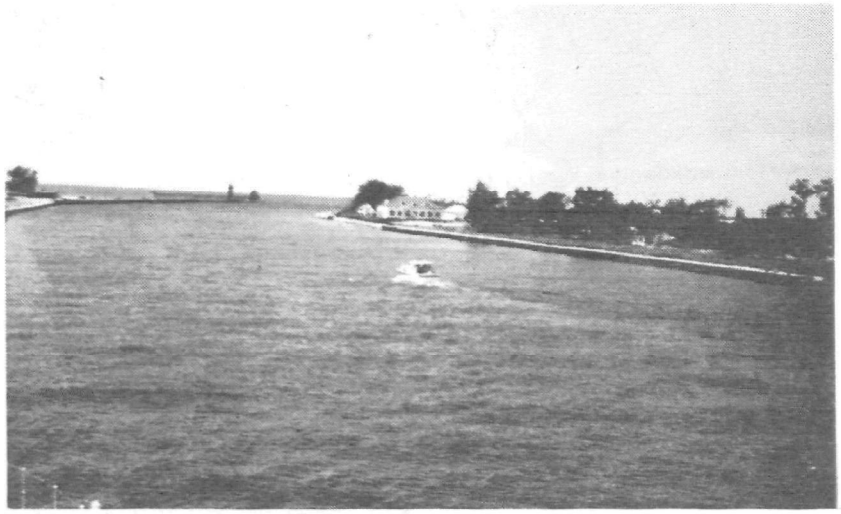
SHORELINE RECREATION

FIGURE 4



RECREATION HARBORS

FIGURE 5



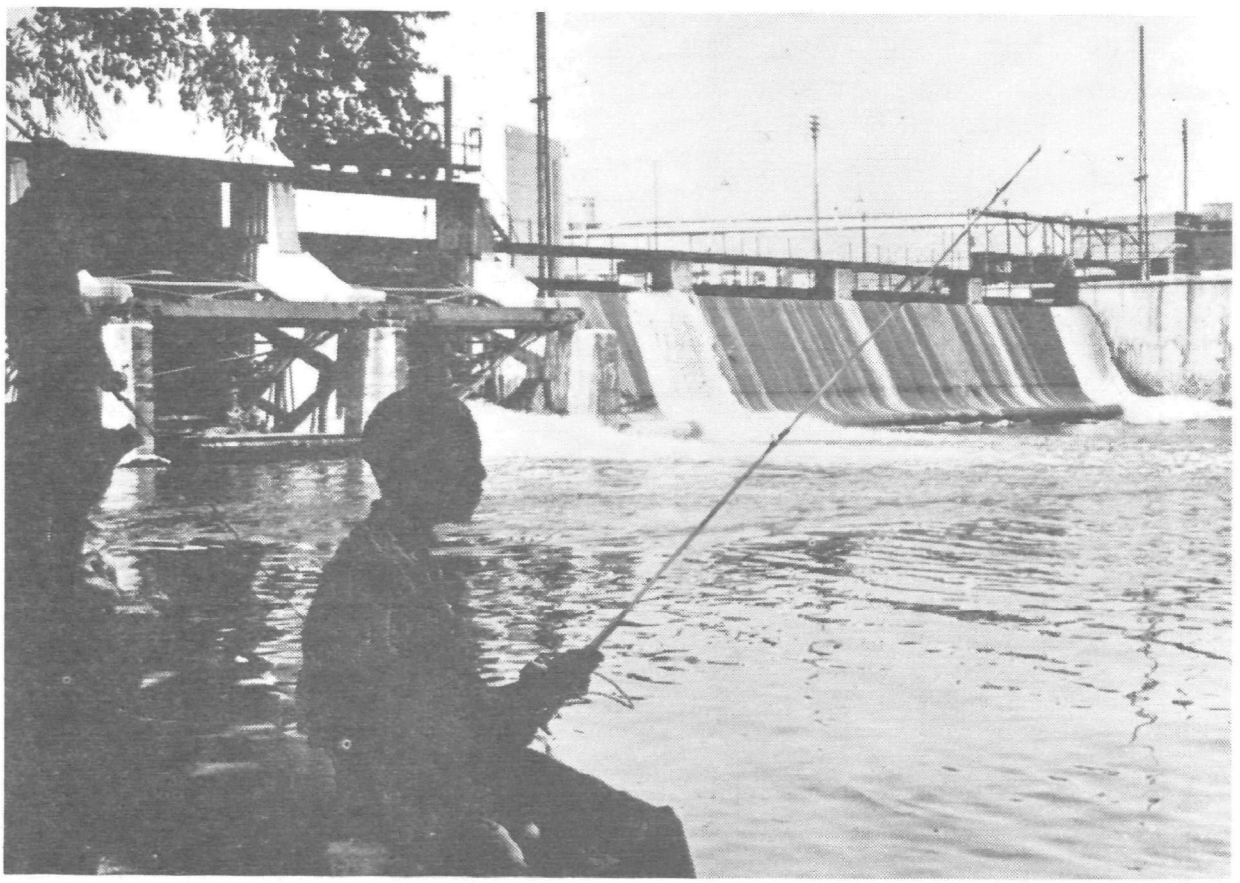
A pleasure boat heads toward the harbor mouth and the open waters of Lake Michigan. There are 74 recreational harbors on the Lake.

In 1960, there was a total of 82 million activity days of water oriented recreation and 94 million activity days of water related recreational activities. It is estimated that the demand for water oriented activities could increase to 247 million activity days by the year 2010, if adequate facilities are provided.

A listing of the areas where recreation is impaired by water quality would be a long one; however, major areas are the Menominee River, Lake Winnebago, the Fox River and the southern portion of Green Bay in Wisconsin, the Calumet harbor area near Chicago, and at the shore lines near the larger cities and harbors. The problems are caused by excessive coliform counts from inadequately treated sewage, combined sewer overflows, vessel wastes and agricultural activities. The over-fertilization of the lake results in algal growth which makes the waters objectionable for body contact. Occasionally, fish kills, due to polluting agents, are also responsible for unsatisfactory condition.

Sport fishing is the second largest form of water oriented recreation, and unlike swimming, which is the largest, cannot be duplicated in a man-made facility such as a swimming pool. The Fish and Wildlife Service in its report (16) estimates 19 million angler days per year are spent in the Lake Michigan Basin. This is expected to triple by the year 2010. To satisfy this demand, particularly in the locality of the densely concentrated

population, a strong effort is required to retain and restore pure water, both in Lake Michigan and its tributaries which are the major spawning grounds of the sport fish.



Fishing in Lake Michigan and its tributaries is the second largest form of water recreation around the lake, topped only by swimming.

The value of the Lake Michigan Basin for recreation and plain esthetic enjoyment, which is part of most recreational uses, is difficult to measure. It is, however, recognized as a significant portion of the economy of the basin. One only has to look at the premium prices paid for purchases and rental of apartments or cottages with a lake view or observe the number of people who will go out of their way to take a lake shore drive, as opposed to a more direct route, to get an indication of the esthetic value of Lake Michigan. A more indirect way of measuring its value is by the amount that is spent annually for recreation in the basin -- for lodging, food and recreational equipment such as boats and fishing tackle. There is no detailed tabulation on this available, but one need only visit several of the prime recreation areas in the Basin to see the investment in recreational facilities.

III - WATER POLLUTION PROBLEMS

When Lake Michigan and the thousands of smaller lakes that dot its watershed were formed, the depressions left by the receding icecap were initially filled with water characterized by a high degree of purity. It is appropriate to note, however, that purity and ideal quality for man's purposes are not synonymous. Biologically speaking, the lakes at formation were a sort of water desert, lacking the necessary ingredients to support either desirable or undesirable life forms. Ever since the lakes were formed, their quality has undergone continuous and progressive change, as a result of waste inputs from both natural phenomena and the activities of man. Some of the effects of this deterioration in quality are readily apparent, while others are revealed only in subtle warning signs of trouble to come unless action is taken. Some of the problems of Lake Michigan and its tributaries are described in the following.

Cladophora algae cling to a rock in the water near Saugatuck, Michigan, a southern Michigan resort area.

EUTROPHICATION

A biologically healthy lake contains a myriad of living organisms, ranging from elemental one-cell life forms upward through successively more complex forms to fish. A balanced aquatic life system can be visualized as a pyramid, in which each successive level forms a link in the food chain that sustains the higher levels. At the base of this pyramid are one-celled plants called algae, which are microscopic in individual size but visible when clustered in colonies. Algae form the base of the food chain; they are capable, through photosynthesis, of utilizing inorganic (non-living) elements in support of growth. (17) Many inorganic elements are required for algal cell growth, including nitrogen, phosphorus, potassium, calcium, and iron -- as well as certain organic substances, required in minute quantities. Parts of Lake Michigan and many other lakes in the Basin are richly endowed with the right elements and conditions to support the growth of algae; and therein lies the problem. (18)

An over-production of algae is occurring, which upsets the normal life balance in the lakes, impairs many water uses, and accelerates the normally slow aging process, called eutrophication, by which a lake evolves into a marsh, and ultimately becomes completely filled with detritus and disappears. One group of filamentous green algae that has been especially troublesome is called Cladophora. In suitable environments these plants attach to any firm object in the water and grow, by cell division, into strings which will vary in length, from a fraction of an inch where nutrients are scarce, to several feet in nutrient-rich waters. Growths of Cladophora have been observed in the southern end of Lake Michigan for many years; but, where small tufts occurred ten years ago, there are now mats with filaments several feet long. These growths are periodically broken loose by wave action and wash ashore to litter the beaches in slimy windrows. They clog water intake screens and interfere with swimming. When they decay they produce a putrid odor and provide a breeding place for flies and other insects.

While the ultimate fate of Lake Michigan, as other lakes, is inevitable, its useful life span can be prolonged thousands of years by timely and continuing action. The present overgrowth of algae can be controlled, and the accelerated aging of Lake Michigan and other lakes can be arrested, by reducing the supply of one or more of the elements needed for growth of algae. The element most amenable to such control is phosphorus. Many experiments, on both laboratory and field scale, have demonstrated the feasibility of regulating algal growth by varying the quantities of phosphorus (in the form of soluble phosphates) available.

The extensive volume of data collected in the study of Lake Michigan and its tributaries permits making an estimate of the relative amounts of phosphate contributed annually from its principal source categories. About two-thirds of the present annual supply of phosphate going into Lake Michigan (estimated to be about 15 million pounds) comes

Algae are shown growing in abundance in one of the lake's tributaries.

Windrows of algae washed up on many Lake Michigan beaches last summer (1967). The above scene is Calumet Park beach in Chicago, Illinois.

from municipal and industrial wastewaters. The other third is a composite of all non-point sources, carried in solution and transported into the lake by its tributary streams. An unknown fraction of this latter third is natural in origin; it gets into the water by leaching from soils and rocks on the watershed. At the same time, a sizable portion of this third undoubtedly stems from man's activities -- from livestock manure, wastes from dairying operations and slaughtering, and the residue from applications of phosphate-rich fertilizers to farm lands. Therefore, some part of this third of all phosphate inputs is amenable to reduction.

Wherever phosphate-bearing waters can be captured and put through a treatment plant, techniques are now available for removing a high percentage of the phosphate content, at reasonable cost. The main reason this has not been done extensively in the past appears to be that removal of phosphates has only recently come to be recognized as an important function of sewage treatment plants. In fact, most municipal sewage treatment plants have not even analyzed their waters to obtain records of phosphate content before and after treatment. In some places where this has been done, and plant modification effected, a large reduction of phosphate has been achieved. Notable among these are San Antonio, Texas and Milwaukee, Wisconsin -- the latter being the largest single point source of phosphates on the Lake Michigan watershed.

The Milwaukee Sewerage Commission has in progress a demonstration project, partly financed by a grant from the Federal Water Pollution Control Administration, to demonstrate the feasibility of and further improve the effectiveness of phosphate removal in an activated sludge treatment plant.

Improvement in the design and operation of conventional treatment plants which provide the so-called secondary, or biological, form of treatment is a necessary first step toward removing nutritive material from wastewaters. There is growing conviction, however, that more will be required in the Lake Michigan Basin, at least at the larger plants where advanced waste treatment can be added at reasonable unit cost. The standard treatment plant of the future in the Great Lakes Basin may be some form of 3-stage treatment: physical, biological, and chemical. It is important to note that this will not render obsolete the 2-stage, i.e., secondary, treatment plants now existing or planned. Rather, the third stage, of chemical precipitation and further solids removal, would be applied to the effluent from the first two -- and each stage supplements the others.

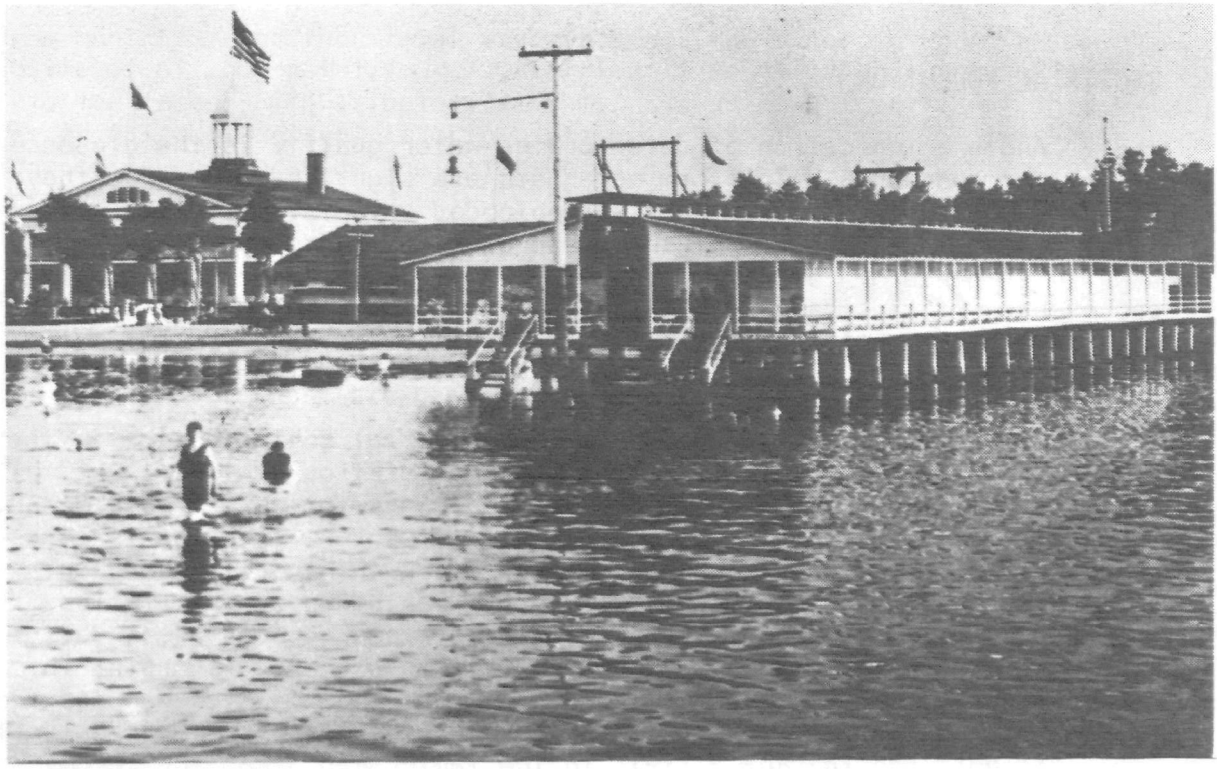
Summing up what has just been said: eutrophication is a threat now, to the usefulness of Lake Michigan and other lakes within the Basin; feasible methods exist for bringing this problem under control. They need to be applied.

BACTERIAL POLLUTION

Another indication of deteriorated water quality is the presence of coliform bacteria. Coliform organisms are significant because they occur in the fecal matter of all warm-blooded animals, including man. Consequently, the presence of these bacteria in a body of water is usually evidence of fecal contamination. Since such contamination is one avenue of transmission of certain waterborne diseases, the presence of coliforms is an indication of health hazard from accompanying pathogenic bacteria and viruses.

Generally, the severe problems of bacterial contamination in the Lake Michigan Basin are located around the population centers. But, of course, this is precisely where the great demands for water usage occur. Studies have shown that the bacterial quality of Lake Michigan is generally good in deep water but is degraded along the shoreline and in harbor areas. Evidence of severe bacterial pollution of tributaries has been found in the Fox River between Lake Winnebago and Green Bay, Wisconsin; the Milwaukee River within Milwaukee County, Wisconsin; in and downstream from the cities along the Grand River in Michigan and the St. Joseph River in Indiana and Michigan; and the streams of the Calumet Area, Illinois and Indiana. (19) In the last-named area, the recommendations, to provide disinfection, of an interstate enforcement conference described elsewhere have not yet been fully implemented.

Bacterial contamination has forced the closing of some Lake Michigan beaches, such as the one shown here at Hammond, Indiana.



The Bay View Beach in Green Bay, Wisconsin, was a popular swimming area at the time this picture was taken in 1910. (Photo courtesy State Historical Society of Wisconsin.)

This is the same area as it appears today. Swimming has been prohibited for many years because of water pollution. (Photo by Bureau of Outdoor Recreation.)

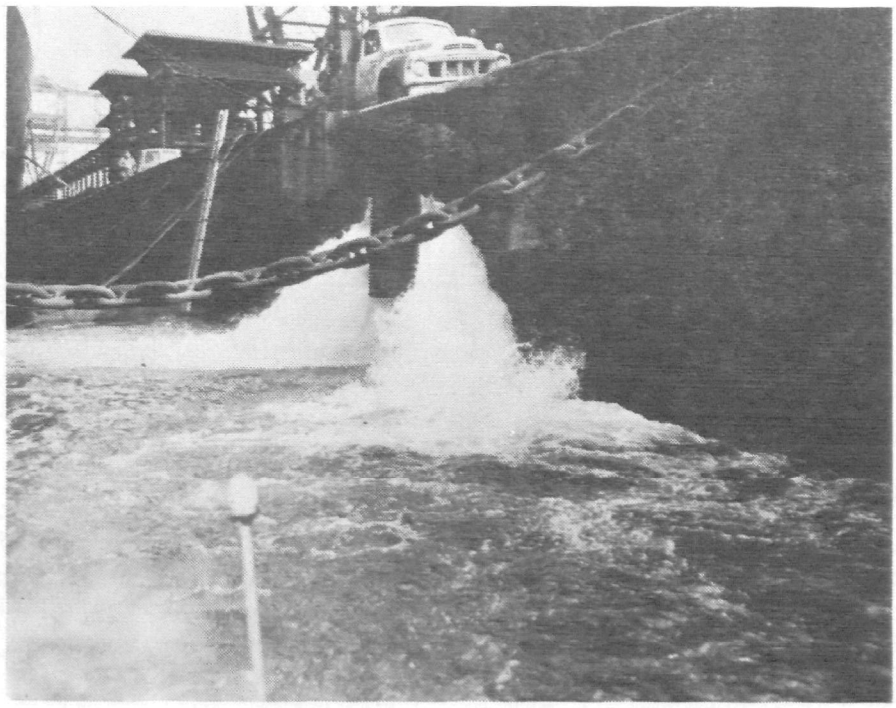
A number of Lake Michigan beaches are closed, either intermittently or permanently, because of health hazard. Permanently closed are some beaches in the Calumet Area and a beach at the southern end of Green Bay. The latter area exhibits also an example of the eutrophication discussed earlier. The Bay View Beach (City of Green Bay) was closed many years ago because of bacterial pollution; over the ensuing years, the beach's custodians understandably got tired of spending time and money each year to clear aquatic growth from waters that were not usable anyway. The beach is now clogged with aquatic weeds and its once-sandy bottom now covered with the dead and decaying remains of weed crops of previous years -- a product of overfertilization. (7)

Bacteria are easily destroyed by disinfection, wherever the waters can be put through a treatment plant. Unfortunately, most of the cities on the watershed are served by combined sewer systems, so that large quantities of a mixture of storm water and sewage are discharged without treatment during and after every heavy rain. This pollutional overflow is the reason that Milwaukee beaches on Lake Michigan have to be closed part of the time.

CHEMICAL POLLUTION

Pollution of Lake Michigan and its tributaries by dissolved chemicals covers a broad range of substances, effects, and sources, the principal source being industrial wastewater effluents. Two general types of effects are produced: 1) local and immediate effects in the vicinity of the discharge point, and 2) a progressive buildup in the concentrations of certain persistent chemicals in the lake as a whole. Regarding the latter, Lake Michigan has experienced an overall increase in average concentration of such dissolved constituents as chlorides, sulfates and the hardness-producing salts. (20)

Areas of local pollution exist around centers of industrial activity and commercial shipping, especially the Calumet Area at the south end of the lake, Milwaukee harbor and its tributary streams, and the southern end of Green Bay. Contamination takes the form of oil, phenolic compounds or other persistent organic chemicals contributing to taste and odor problems, ammonia and other nitrogenous materials, phosphorus, suspended matter, and highly acidic or alkaline materials. Conditions in the Calumet Area have been extensively documented in connection with the ongoing enforcement action relative to its interstate waters. (21) Details concerning the Milwaukee area and the Green Bay area are given in reports published by FWPCA last year. (22 & 23)



The heavily industrialized south end of Lake Michigan suffers severe water pollution problems. This is a waste outfall located on the Indiana Harbor Ship Canal in East Chicago, Indiana.

OXYGEN DEPLETION

The small quantity of oxygen normally dissolved in water is perhaps the most important single ingredient necessary for a healthy, balanced, aquatic life environment. Dissolved oxygen is consumed by living organisms through respiration and is replenished, if a well-balanced environment exists, by absorption from the atmosphere and through the life processes of aquatic plants. When organic pollution enters this environment, the balance is altered. The bacteria present in the water or introduced with pollution utilize the organic matter as food and multiply rapidly. The resulting oxygen deficiency may be great enough to inhibit or destroy the fish and other desirable organisms and to convert the stream or lake into an odor-producing nuisance.

At present, the main body of Lake Michigan has not shown signs of oxygen deficiency -- even in its bottom waters, where an oxygen deficit is frequently observed in eutrophic lakes and in manmade reservoirs. Oxygen depletion is a common occurrence, however, in many of the Lake Michigan tributaries. Especially bad in this respect are the Fox River in Wisconsin, between Lake Winnebago and Green Bay; and the tributary streams of the Calumet Area, including the Little Calumet River, Grand Calumet River, Indiana Harbor Canal, and Indiana Harbor. Other zones of periodic oxygen deficiency are: the Grand River in Michigan downstream from Jackson and Lansing; the Menominee River in certain stretches along the boundary between Wisconsin and

Michigan, the Milwaukee River and Milwaukee Harbor; the Kalamazoo River, Michigan; and the St. Joseph River, Michigan and Indiana, and the southern end of Green Bay. In general the discharge of treated and untreated municipal and industrial wastes in these areas produces these polluted conditions. The high concentrations of biochemical oxygen demand (BOD) in the waste discharges combine, in some cases, with severe drought flows of receiving waters to intensify the problems of this nature.

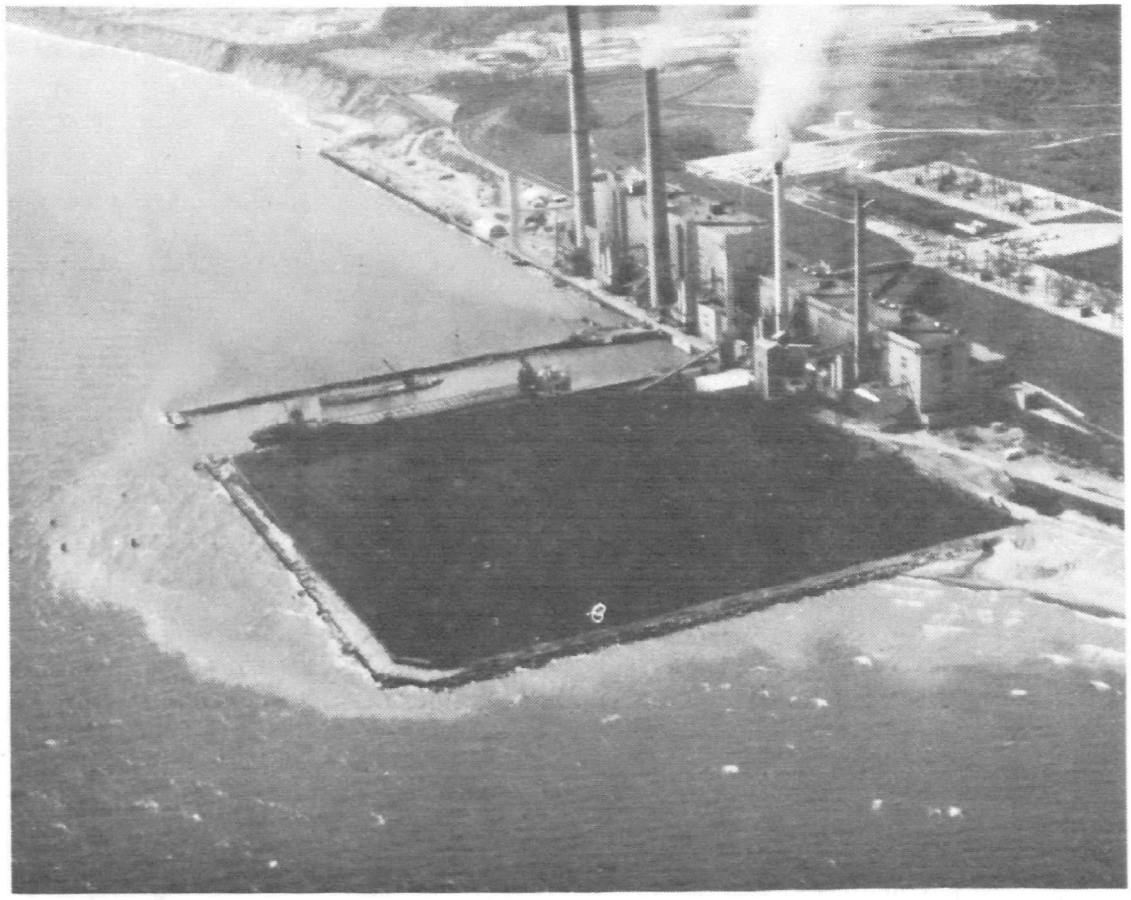
This load of detergents has been discharged by the Jackson, Michigan, sewage treatment plant into the Grand River, a Lake Michigan tributary.

ELECTRIC POWER PLANTS

Lake Michigan has been an attractive location for large electric power plants. Two principal reasons are the ready availability of a large quantity of cooling water, and the proximity to the large market of its cities and industries. The greatest concentration of power plants is around the southern basin, from Milwaukee southward. Within this area are located six major power plants having a total installed capacity in excess of 4.5 million kilowatts, and some 20 smaller plants, either public utility or private industrial, which bring the total capacity of plants in the southern basin to about 6 million kilowatts. These are fossil-fueled plants, burning either coal or gas. (13)

The Nuclear Power Age has come to the Great Lakes area with dramatic suddenness within the last few years. One of the earliest full-scale, commercially-operated, nuclear power plants is the existing plant at Big Rock Point, Michigan, near the northern end of Lake Michigan. Five additional plants are proposed or under construction, 3 of which will have twin reactor units, and all of which are scheduled for completion between 1970 and 1973. The three largest of these plants

will be located in the southern basin and have a total installed capacity of 5 million kilowatts. Thus, by 1973 the southern basin of the Lake will be ringed with power plants having an electrical output of 11 million kilowatts -- 6 fossil-fueled and 5 nuclear-fueled (see Figure 6).

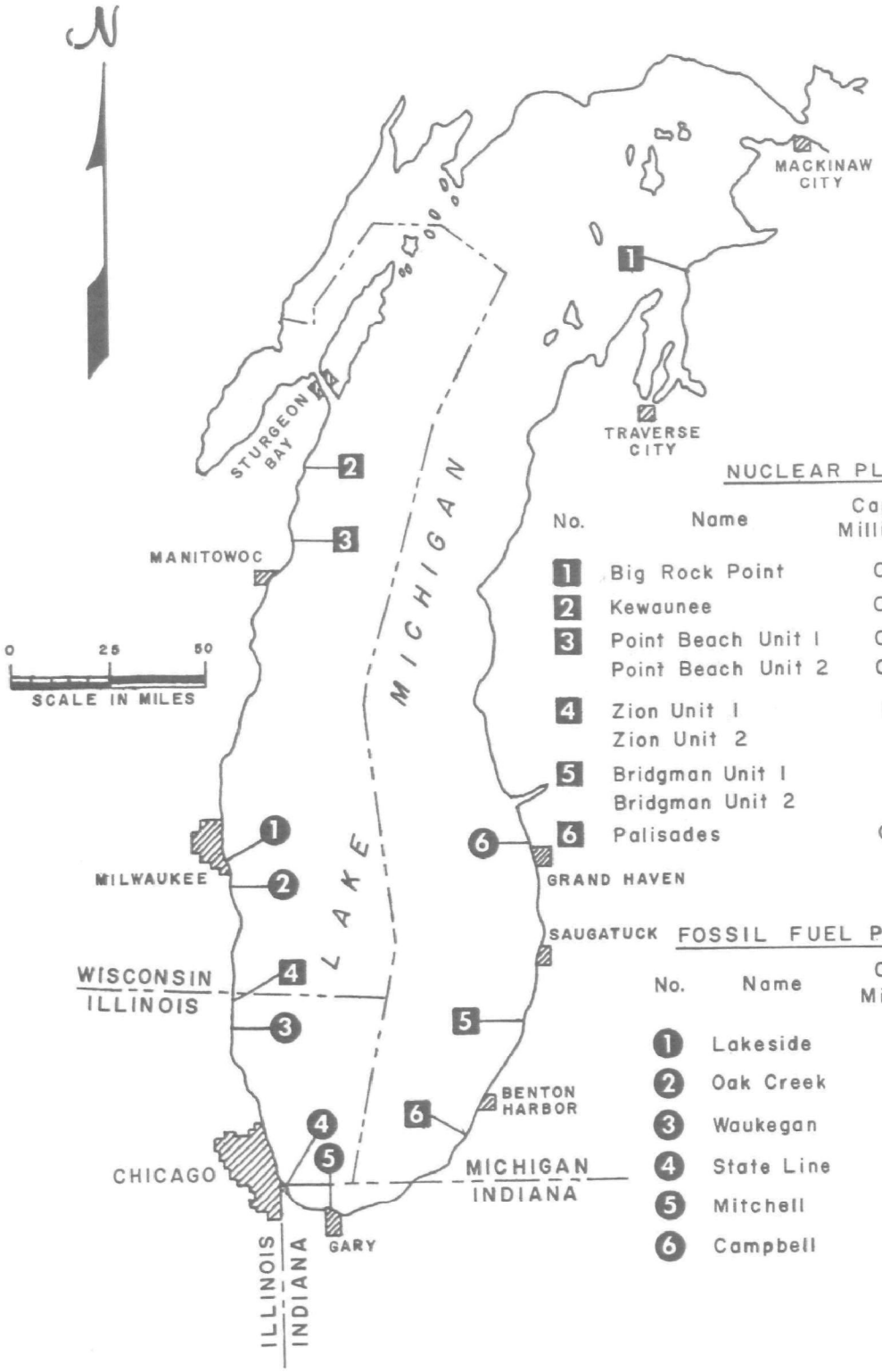


Wisconsin Electric Power Company at Oak Creek, Wisconsin, south of Milwaukee, is one of the many power plants located in the southern basin of Lake Michigan.

Power plants are of concern to water quality because both types add heat to the Lake Michigan water, and nuclear plants also discharge some waste radioactivity to the water.

Waste Heat

The typical thermal power plant converts heat energy to electric energy, wasting large quantities of heat in the process. In the present status of the art, a fossil-fueled plant wastes about 1.5 units of heat for each equivalent unit of useful energy output; a nuclear-powered plant wastes, for comparable output, about 2.25 units of heat energy. (In technical terms, fossil-fuel and nuclear plants reject respectively 4,900 and 7,800 BTU per kwh.) This waste heat, in either type, is conducted from the plant in the cooling water and subsequently



NUCLEAR PLANTS

No.	Name	Capacity Million KW	Completion Date
1	Big Rock Point	0.07	1963
2	Kewaunee	0.53	1972
3	Point Beach Unit 1	0.45	1971
	Point Beach Unit 2	0.45	1972
4	Zion Unit 1	1.10	1972
	Zion Unit 2	1.10	1973
5	Bridgman Unit 1	1.10	1972
	Bridgman Unit 2	1.10	1972
6	Palisades	0.70	1970

FOSSIL FUEL PLANTS

No.	Name	Capacity Million KW
1	Lakeside	0.31
2	Oak Creek	1.35
3	Waukegan	1.09
4	State Line	0.88
5	Mitchell	0.41
6	Campbell	0.65

MAJOR POWER PLANTS

FIGURE 6

dissipated into the environment -- the ambient air, or receiving waters, or some combination of both. Power plants on Lake Michigan are not usually equipped with cooling towers for transfer of heat to the air, so that the bulk of this waste heat goes first into the water of the Lake.

Heat added to Lake Michigan produces two effects: 1) it creates a local zone of water warmer than the natural background temperature, and 2) it warms, albeit imperceptibly, the whole body of lake water and the air above it. Regarding the second effect, the critical body of water would be that contained in the epilimnion (upper layer) of the southern basin of the lake, and the critical period would be the summer months, when water and air temperatures are warmest and stratification inhibits the dispersal of the input heat to a greater volume of lake water. An estimate has been made of the overall warming effect of power plants on the lake zone just delineated. Assuming the power plants to operate with an average output equal to 80 percent of plant capacity, and assuming no escape of the input heat from the water (a conservative assumption), the combined effect of existing plants plus the proposed nuclear plants would not raise the overall average water temperature by as much as one-tenth of a degree Fahrenheit. Even this minute increase in water temperature would be nullified during the following winter, so that no progressive warming tendency for Lake Michigan, attributable to power plants, is expected to occur.

This focuses attention on the first effect cited -- the local zone of warm water created in the immediate vicinity of a power plant discharge. Again citing a typical Lake Michigan power plant, it will have a pipe or tunnel conduit bringing water from an intake located perhaps a few thousand feet offshore; as the cooling water flows through the plant its temperature will be increased by 10 to 20 degrees F.; the used water will be returned to the lake at or near the shoreline. Since the water at the point of intake will be somewhat colder than the shallow water at the point of discharge, it can be expected that the discharging water may be on the order of 10 to 15 degrees warmer than the lake at that point. The local warm water zone will thus have a peak temperature some 10 to 15 degrees warmer than the background temperature. Some of this heat will be transmitted to the ambient air; the rest will transfer into lake water by a combination of dilution and convection, until the local water temperature merges with and becomes indistinguishable from that of neighboring water. The areal extent of this warm water zone will depend upon the incremental temperature rise, and the rate at which heated water is being put in -- and the latter will depend on the size and design of the power plant.

If the local warmwater zone occurs where the lake bottom has suitable attachment surfaces, it could promote a luxuriant crop of filamentous algae (Cladophora). The detrimental effects of an overgrowth of algae have been described elsewhere. It is sufficient here to point out that conditions are favorable for promoting over-

production of algae in many parts of Lake Michigan; and that anything which may further promote their growth is to be viewed with concern.

Radioactivity

Most of the six commercial nuclear power stations (9 units) built or planned in the Lake Michigan Basin are of the light-water type, operating on the pressurized water principle. "The water of the primary coolant system passes through a heat exchanger in which the heat is passed to the water of a secondary cycle in which steam is produced for use by a turboelectric plant. The primary cycle coolant, after passing through the heat exchanger, is returned through pumps to the reactor for reheating. The two-loop system is used to prevent fission products from entering the turbines and thereby complicating maintenance operations and adding to the complexity of radiation protection. In the event of a fuel-element failure in a two-loop reactor, the fission products remain in the primary system and do not contaminate either the secondary system or the turbines." (24)

Primary and secondary coolants are passed through ion-exchange resins to remove activation products and fission products resulting from fuel-pin failures. "In the operation of a nuclear power plant, there are many operations which produce contaminated liquids. Leaks of primary water from valves, flanges, and pumps will ultimately result in the contamination of sump water. Components which are removed for repair must first be decontaminated, and this will result in contaminated water, as will the operation of washing casks, sluicing resin beds, laundering contaminated clothes, and washing contaminated laboratory ware. In addition, it may be expected that the cooling pools for spent fuel may in time become contaminated as a result of failures in the fuel element cladding." (24) Provisions are made for containment, treatment, and ultimate disposal of these waste liquids. High-level wastes are shipped to burial sites but low-level wastes are diluted and discharged to the environment.

All liquid and gaseous radioactive waste discharges from nuclear power plants are limited by Atomic Energy Commission (AEC) Rules and Regulations (10CFR20) or State regulation where they apply. However, the AEC limits are set above "natural background." Since "natural background" is not defined, the Rules can be interpreted in three ways: 1) discharges are limited to concentrations in excess of pre-World War II levels; 2) discharges are limited to concentrations in excess of pre-operational levels; or 3) discharges are limited to concentrations in excess of cooling water intake levels. None of these interpretations are desirable. In the case of 1), pre-World War II levels are not known, since the technology was not developed to measure minute quantities of radioactive materials. Interpretation 2) would be adequate except that each additional reactor would have a higher baseline on which acceptable waste discharge levels would be determined, since preoperational levels for a new reactor would be post-operational for a previously built reactor in the same watercourse. Case 3) is wholely unacceptable because there would be essentially no limit to quantities discharged.

Since the original standards were promulgated on the basis of a moving stream receiving the radioactive effluent, and since Lake Michigan has a very small discharge rate, any radioactive waste material entering into it will diminish only by natural decay. This may result in significantly increased levels of the longer-lived radioisotopes. The AEC Advisory Committee on Reactor Safeguards, October 12, 1966 (AEC News Release No. IN-725 dated October 25, 1966), made the following statements and recommendations:

"The dilution, dispersion, and transport of liquid radioactive wastes in surface waters (rivers, lakes, estuaries, bays and open ocean) are important factors in the siting of nuclear reactors. In addition to these phenomena, attention frequently needs to be directed toward biological concentration of radionuclides in aquatic life. It may be desirable to review previous work on this subject, including related research on discharge of municipal and industrial liquid wastes. Preparation of a state of the art review of current knowledge, and delineation of areas where further research is needed, would be useful. A special evaluation of the impact of siting many reactors on the shores of the Great Lakes, in relation to retention and flushing characteristics and to accumulation of radionuclides in aquatic organisms, may also be desirable."

WASTES FROM WATERCRAFT

Vessels of all types, commercial, recreational and Federal (Corps of Engineers floating plant, Coast Guard cutters and Naval Reserve Training Ships) plying the waters of Lake Michigan and its tributaries are contributors of both untreated and inadequately treated wastes in local harbors and in the open lake, and intensify local problems of bacterial pollution.

A report entitled "Pollution of Navigable Waters of the United States by Wastes from Watercraft" (25), was submitted to the Congress on June 30, 1967 by the FWPCA. This report recognizes and analyzes the serious problems that are caused by all types of watercraft, including pollution from sanitary, garbage and oil wastes. Implementation of the recommendations made in this report by the Congress will provide an effective means for combating the vessel waste problem on Lake Michigan. FWPCA has proposed legislation to Congress, based on this report.

Some significant progress has been made in the abatement program on Lake Michigan. The City of Chicago recently enacted an ordinance prohibiting the discharge of all wastes from vessels and shore installations into the portion of the lake within the city's jurisdiction.

OIL POLLUTION

One of the problems in the Lake Michigan drainage basin is oil pollution. Discharges from industrial plants and commercial ships,

and careless practices in loading and unloading cargos, cause contamination of water in many areas. Oil discharges and spills produce unsightly conditions which affect beaches and recreational areas, contribute to taste and odor problems and treatment problems at water treatment plants, coat the hulls of pleasure craft, and in some cases are toxic to desirable fish and aquatic life.

The Oil Pollution Act of 1924 prohibits the discharge of oil by vessels in the waters within the United States. The FWPCA was made responsible for enforcement of this Act by the Clean Waters Restoration Act of 1966. Oil pollution in navigable waters from any source which is a hazard to navigation is the responsibility of the Corps of Engineers as authorized by the Rivers and Harbors Act of 1899. The Coast Guard provides support to both the Corps and FWPCA.

Oil pollution is a serious problem at the Indiana Harbor Ship Canal, East Chicago, Indiana. Inland Steel Company's turning basin on the canal is often coated with oil.

Although oil contamination has been observed in many areas of the Basin as shown on Figure 7, the principal location in which it occurs is the Calumet Area in Illinois and Indiana. Table 2 shows the number of oil discharges and spills reported by the Coast Guard in 1967. The number of discharges and spills indicates the need for greater care in transportation of oil by commercial ships, and the need for separation of oil from industrial waste to reduce the effects of oil contamination on the public waters.

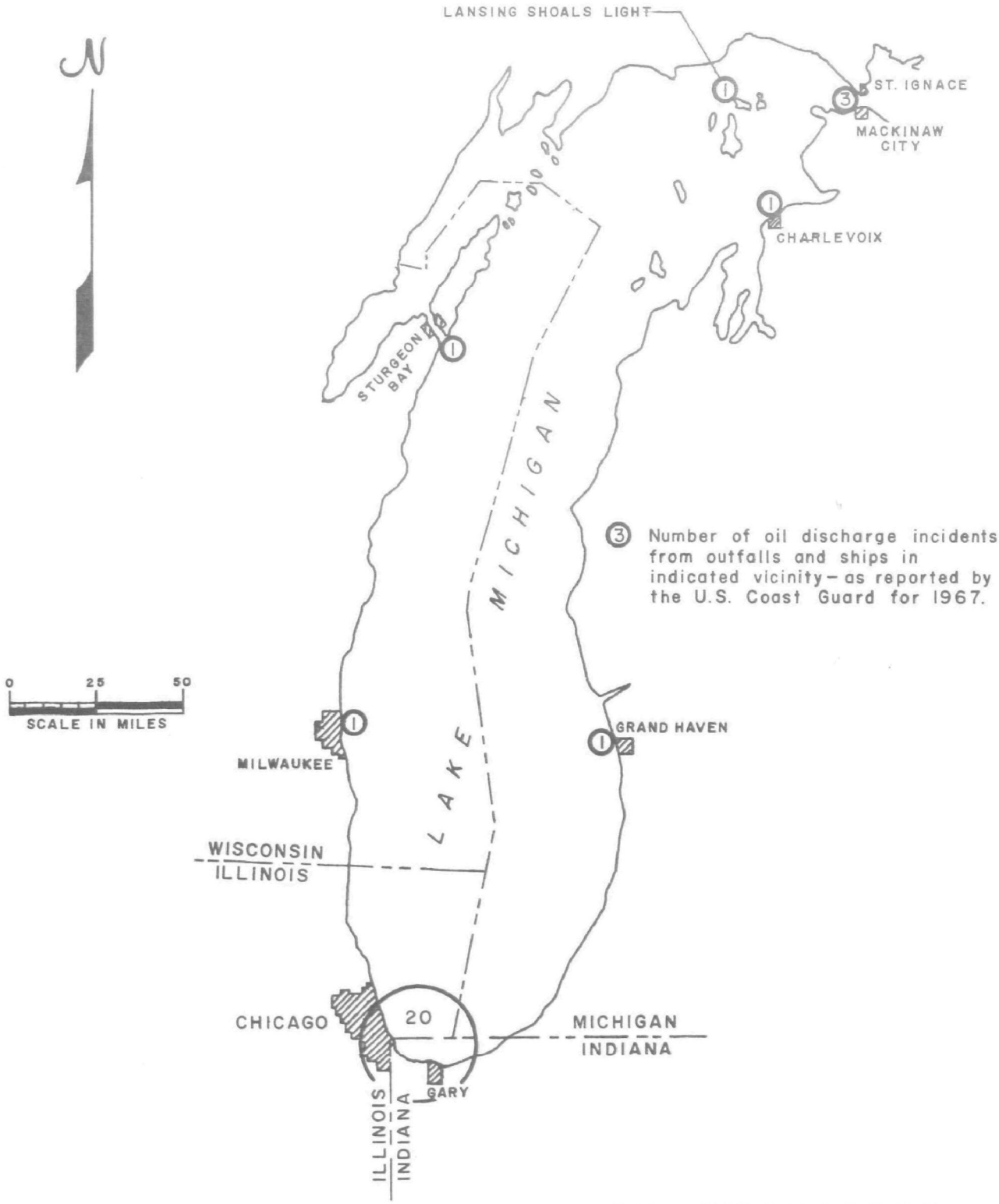
The Torrey Canyon ship disaster, which involved a major spill of oil off the coast of England in 1966, focused attention on the detrimental effects of oil contamination on recreational facilities and on fish and aquatic life. It also pointed up the need for additional study of existing resources and techniques to deal with spills of this magnitude should they occur again. On May 26, 1967 the President of the United States asked the Secretaries of Interior and Transportation to undertake a joint study to determine how best to mobilize the resources of the Federal Government and the Nation to cope with the problems of major oil spills and other pollutants and hazardous substances and their adverse affects.

One of the major needs disclosed by the study was the development of a contingency plan to deal with an emergency involving Federal, State and local agencies with due regard for each agency's statutory responsibility and capability. Preliminary coordination has been effected by FWPCA with the Corps of Engineers and the Coast Guard throughout the Region to develop such a plan.

DISPOSAL OF DREDGED MATERIAL

Responsibility for improvement and maintenance of the waterways of the United States in the interest of navigation has been delegated by Acts of Congress to the Corps of Engineers. In carrying out this responsibility, the Corps dredges approximately 10 million cubic yards annually from Great Lakes harbors, and in fiscal year 1966 dredged 1-1/2 million cubic yards from harbors on Lake Michigan (see Figure 8). The Corps has followed the practice of disposing of most of this material in authorized dumping grounds in the open waters of the Lakes. The nature of the dredged material ranges from grossly polluted sludge to clean lake sand. Private dredging in the vicinity of docks, loading facilities, etc., is accomplished under permit from the Corps.

The interest of FWPCA in the disposal of polluted dredged material dates back to 1948, when a special study was undertaken, in cooperation with the field staff of the International Joint Commission, of the pollutional effects of dredging operations in the Rouge River, at a request of the District Engineer, Detroit District, Corps of Engineers. As a result of this study, the Report of the International Joint Commission, United States and Canada, on the Pollution of Boundary Waters (1951), contained a conclusion that "Dredged material should be disposed of in such a manner and at such locations



OIL DISCHARGES
1967

FIGURE 7

TABLE 2

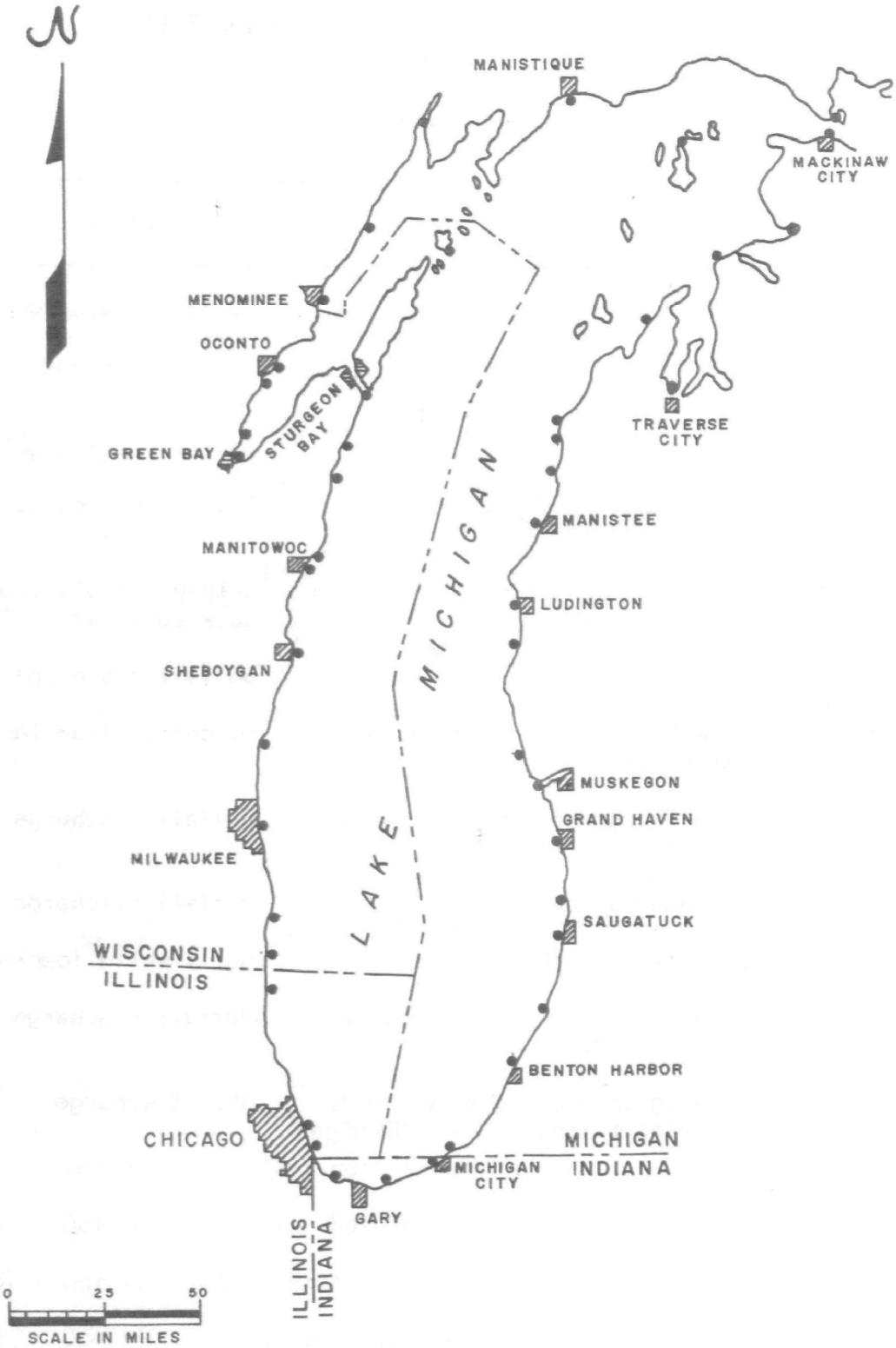
OIL DISCHARGES FROM OUTFALLS AND COMMERCIAL SHIPS REPORTED BY THE U. S. COAST GUARD IN THE LAKE MICHIGAN DRAINAGE BASIN IN 1967

NO.	DATE	LOCATION	TYPE
1	Apr 4	Round Lake, Charlevoix, Mich.	Spill while unloading
2	May 6	Grand River at Grand Haven, Mich.	Spill while refueling
3	May 14	Sturgeon Bay, Wisc.	Spill while unloading
4	Jul 28	South Channel, Straits of Mackinac	Discharge of ships ballast
5	Aug 8	Indiana Harbor Canal	Spill while unloading
6	Aug 9	Chicago & Calumet River and Lake Michigan Area	Leaking ship
7	Aug 10	Straits of Mackinac	Ship discharge
8	Sep 19	Milwaukee Harbor	Leak from tank farm
9	Sep 17-26	Southern end of Lake Michigan	Oil on water and beaches from unknown source
10	Sep 28	Lake Calumet	Discharge of ships ballast
11	Oct 3	Indiana Harbor Canal	Outfall discharge
12	Oct 9	Lake George Branch, Indiana Harbor Canal	Outfall discharge
13	Oct 9	Indiana Harbor Canal	Outfall discharge
14	Oct 10	Indiana Harbor	Outfall discharge
15	Oct 10	East Branch Grand Calumet River	Outfall discharge
16	Oct 11	Indiana Harbor Canal	Outfall discharge

TABLE 2 (Continued)

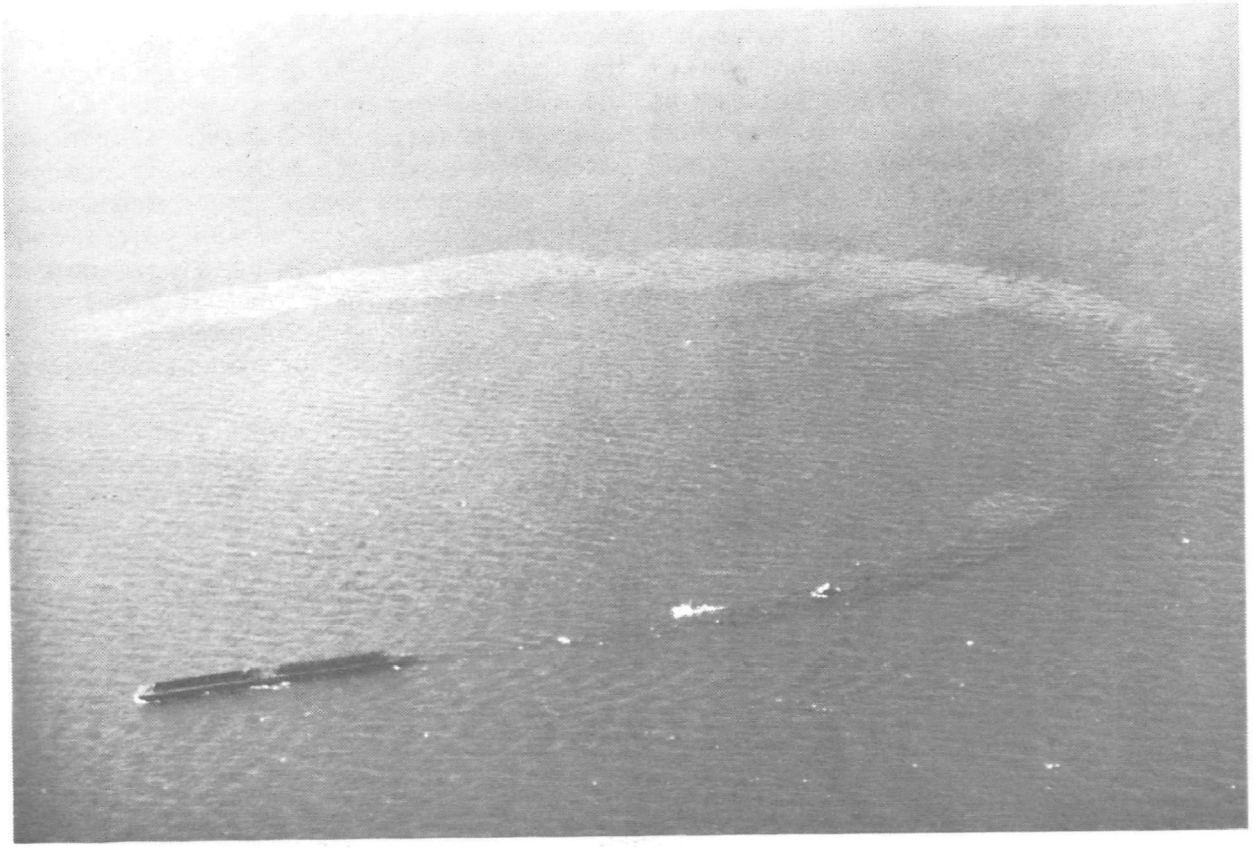
OIL DISCHARGES FROM OUTFALLS AND COMMERCIAL SHIPS
REPORTED BY THE U. S. COAST GUARD IN THE
LAKE MICHIGAN DRAINAGE BASIN IN 1967

NO.	DATE	LOCATION	TYPE
17	Oct 11	East Branch Grand Calumet	Outfall discharge
18	Oct 11	Lake George Branch of Indiana Harbor Canal	Outfall discharge
19	Oct 12	Indiana Harbor	Outfall discharge
20	Oct 12	Lake George Branch of Indiana Harbor Canal	Outfall discharge
21	Oct 12	Calumet River Branch of Indiana Harbor Canal	Seepage of oil from dock bulkhead
22	Oct 13	Indiana Harbor Canal	Outfall discharge
23	Oct 13	Lake George Branch of Indiana Harbor Canal	Discharge from land
24	Oct 14	Lake George Branch of Indiana Harbor Canal	Outfall discharge
25	Oct 14	Indiana Harbor Canal	Outfall discharge
26	Oct 14	Straits of Mackinac	Spill while loading
27	Oct 15	Lake George Branch of Indiana Harbor Canal	Outfall discharge
28	Nov 9	Lansing Shoals light, vicinity of Grand Island in Lake Michigan	Ship discharge



FEDERAL HARBOR PROJECTS

FIGURE 8



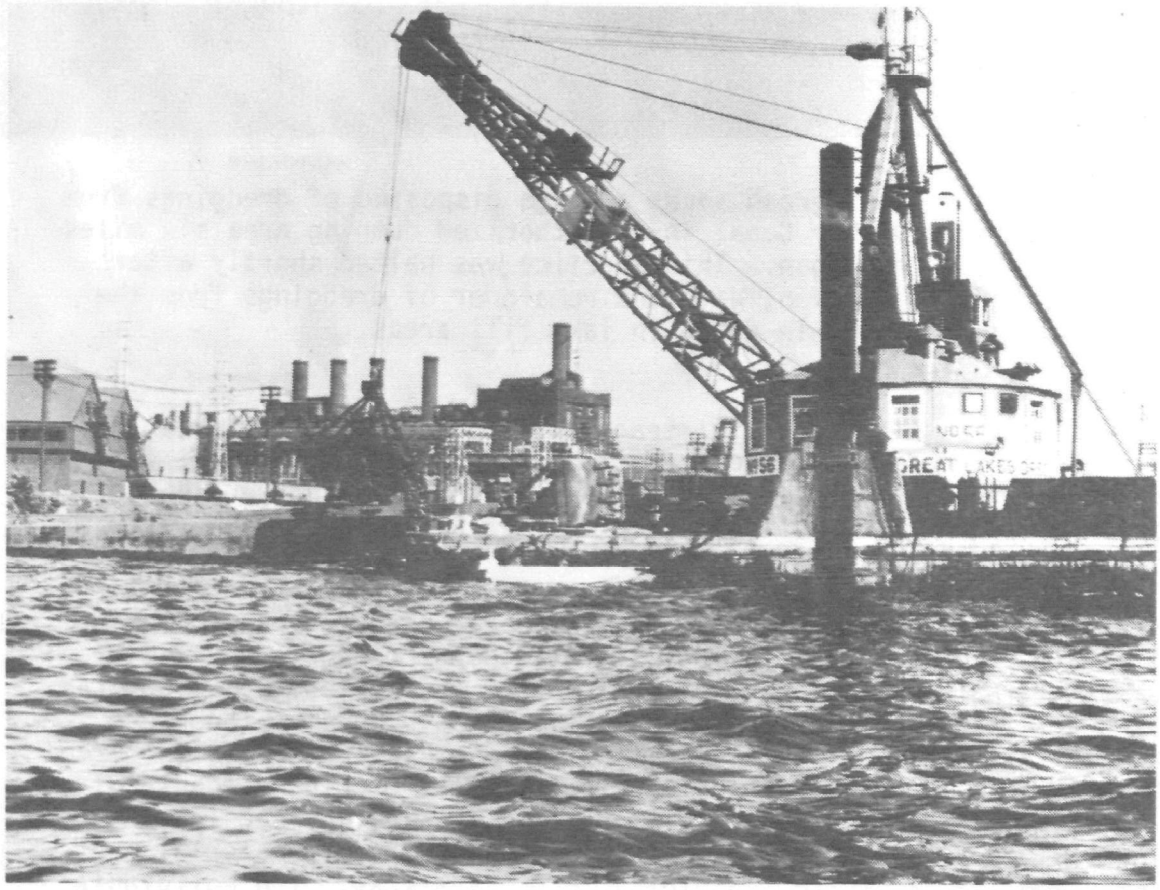
This aerial photograph shows a barge disposing of dredgings from the Indiana Harbor Canal in an authorized dumping area six miles out in Lake Michigan. This practice was halted shortly after this photo was taken, with the remainder of dredgings from the canal disposed of in diked-in lake fill areas.

as will not result in harmful transfer of polluting substances in the waters under reference (the connecting channels)." As a further result of the study, the Corps of Engineers established a diked disposal area on Grassy Island in the Detroit River, for Rouge River dredged material.

More recently, attention has been directed to the problem as a result of water quality studies of the Lakes conducted by the Great Lakes-Illinois River Basins Project during the period 1962-1966. As a result of these studies, FWPCA is concerned about the long-term cumulative effect of incremental additions of pollutants to the Great Lakes. This is particularly important in Lake Michigan because of the minimal flushing action obtainable in this cul-de-sac lake. Among the visible results of open water disposal of dredged material are discoloration, increased turbidity, and oil slicks. The pollutants contained in the dredged material may also contribute to increased concentrations of dissolved solids, nutrients, and toxic materials, which are responsible for deterioration of water quality.

Through a joint statement announced March 1, 1967, the Department of the Army and the Department of the Interior agreed on a program and plan for attacking the problem of the disposition of polluted material dredged from harbors in the Great Lakes. It was agreed that, in order to maintain navigation, the Corps of Engineers would proceed with dredging in calendar year 1967 on 64 channel and harbor projects in the Great Lakes. The Corps also initiated a two-year pilot program early in 1967 to develop alternative disposal methods which would lead to a permanent plan of action. FWPCA is participating in this program, which has the ultimate objective of providing leadership in the nationwide effort to improve water quality through prevention, control and abatement of water pollution by Federal water resources projects.

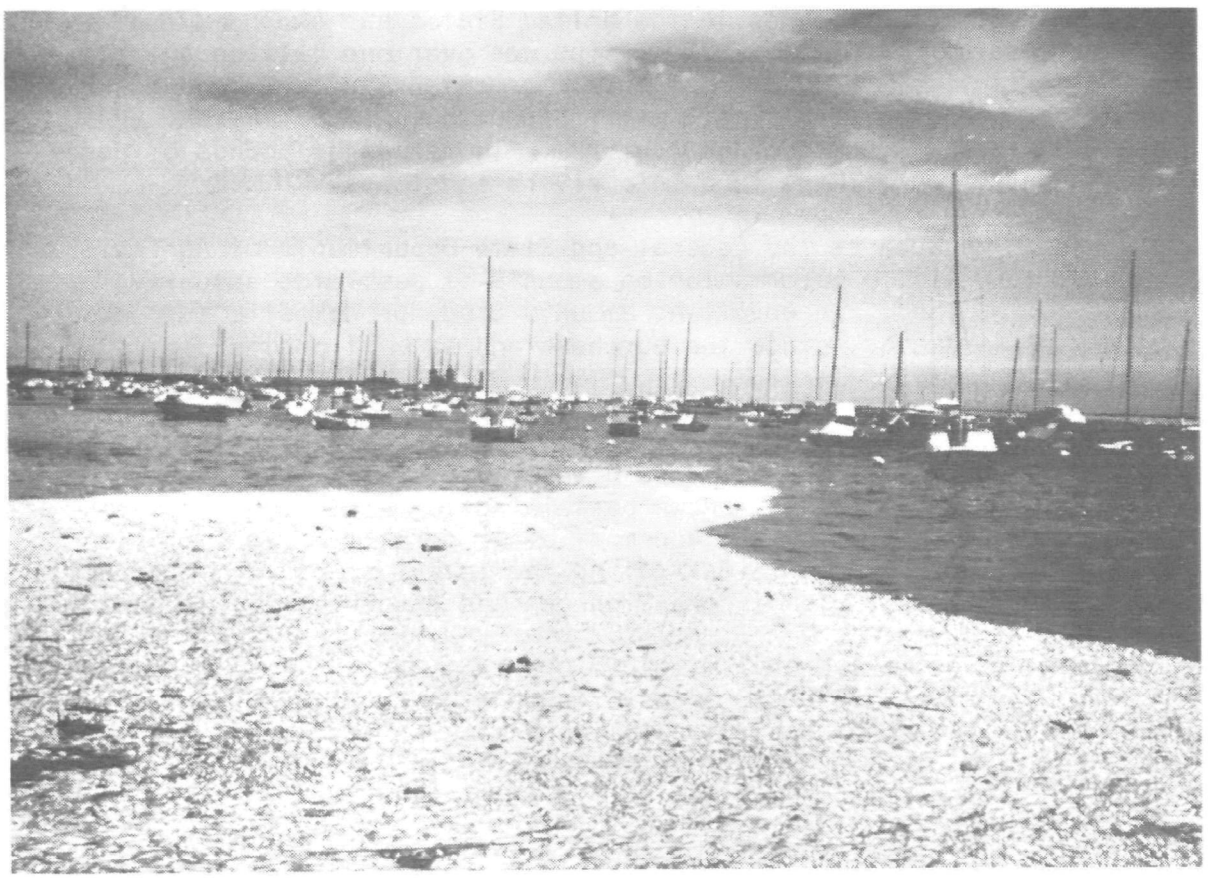
During the past season the Corps of Engineers provided alternate disposal of dredged materials from three of the most polluted harbors on Lake Michigan: Indiana Harbor, Indiana; Calumet River, Illinois; and Green Bay Harbor, Wisconsin. It is expected that alternate disposal will be provided for additional Lake Michigan harbors during the 1968 season.



A dredge hauls muck from the bottom
of Calumet Harbor in Chicago, Illinois.

ALEWIVES

A dramatic example of an upset in the balance of nature is the invasion of the Great Lakes by the alewife. These little fish, decendants of a species which has migrated into the Lakes from the ocean and adapted itself to the fresh-water environment, have become pests mindful of the great locust plagues recorded in history in some land areas of the world. The alewife is a virtually useless fish. They are not good to eat, and there is no sport to catching them. Efforts to find a commercial market for them, as animal food, have been only partially successful. By competing for food supply, they crowd out more desirable species. Worst of all they move in enormous schools from the deeper recesses of the lakes, especially Lake Michigan, into inshore waters and die there by the millions - clogging water intakes and piling up in stinking masses on shores.



Dead alewives litter a Chicago harbor during the alewife die-off of 1967.

The massive influx and die-off of alewives has become an annual event each spring in Lake Michigan and, to a lesser extent, the downstream Great Lakes. It reached record proportions in Lake Michigan last spring and early summer, when deaths estimated in the billions occurred. On that occasion our agency conducted a special water sampling survey to determine the quality of the water and whether water pollution could have played a part in the die-off. All evidence collected indicates that water pollution did not contribute to the deaths.

As a result of a recommendation by a special task force appointed by Secretary Udall, the Interior Department's Bureau of Commercial Fisheries is spearheading the search for further answers to the alewife problem, including ways to bring the alewife population into balance with other aquatic life.

PESTICIDES

The use of pesticides in the United States has expanded rapidly in recent years. The total market value was over one billion dollars, for the first time, in 1964. Usage in the United States increased from 34 million pounds in 1953 to 119 million pounds in 1965. More than 58 percent of this usage was by agriculture. Thousands of pounds of pesticides annually run off the land into rivers and lakes.

Agencies such as the Federal and State Departments of Agriculture have very little information on amounts of pesticide actually applied to the land. In addition, amounts used for domestic purposes can only be estimated, since the purchase and sale of pesticides is in no way controlled.

The use of pesticides has been so loosely controlled that man's environment throughout the world is now permeated with these substances. Scientific facts are not yet known pertaining to the tolerance limits for human beings, birds, fish, and most other forms of life. Limited studies have taken place, investigating the levels of the various pesticides found in the waters of Lake Michigan and its tributary streams.

The places in the Lake Michigan Drainage Basin where pesticides are used most heavily are the areas of extensive fruit growing. These areas are: the Wisconsin portion of the Green Bay watershed; the southeast quadrant of the Lake Michigan Drainage Basin; and the area along the northeast shore from Manistee to Traverse City, Michigan.

An FWPCA study in the Green Bay area was designed to investigate the effects of chlorinated pesticides on the aqueous environment of Green Bay. Agricultural soil, river water, bay water, bottom sediments, and algae were examined. Chlorinated pesticides were detected in all types of samples. Some of the soils tested had as high as 7,800 micrograms per kilogram. Maximum concentration found in bottom sediments was close to 3,000 micrograms per kilogram, which was more than two million times that of the overlying water at the time of the study. The algae contained still greater amounts than did the bottom sediments. The

FWPCA analyses of several drinking water intakes located at various places along the Lake Michigan shore revealed the presence of pesticides in the surface water. Studies by other agencies indicate substantial levels of pesticides in Lake Michigan fish.

Pesticide pollution of Lake Michigan and its tributary streams results from the application of these materials by spraying and dusting. As a result of these methods of application, some of the material falls directly into the waters of the area being sprayed. Pesticides on the soil and crops are washed into the waters by rain and soil erosion.

Water uses affected by the application of pesticides are recreation, fish and wildlife, and water supplies. Up to this time, the extent to which these materials are affecting the water supplies and recreational uses of Lake Michigan has not been precisely determined. However, with the ever-increasing use of these materials, all waters are threatened.

Recent studies have shown that the eggs of coho salmon, recently introduced into Lake Michigan, contain pesticides. It remains to be determined whether these pesticide levels are high enough to have a significant effect on successful reproduction of the coho salmon.

The significance of the synthetic organic pesticides in their high toxicity and their persistence in the environment after the initial application. Kills of fish, other aquatic life, and wildlife often result. In addition, pesticides are absorbed by microscopic aquatic life and subsequently enter into the food chain leading through fish to man and other animals. Purification of water for human consumption, as commonly practiced, is largely ineffectual in removing pesticides in the treatment process.

The synthetic organic pesticides accumulate in fatty tissue, whether fish, fowl, or human. Food and water may both serve as sources of these substances. Lethal levels may be carried in fatty tissue without immediate apparent effect on the organism. When such fatty deposits are utilized, physical and metabolic complications ensue. In addition, combinations of accumulated pesticides may exert synergistic effects, where the total toxic effect is greatly increased. In nature, soils may remain contaminated for years after the initial application.

Each State and the Federal government should reduce pollution resulting from pesticides through the following activities: placing responsibility for control of pesticides in one agency; establishing water quality standards for pesticide levels; obtaining more precise information on total amounts of all types of pesticides used, where such statistics are now unavailable; establishing routine monitoring of drinking water sources for pesticide content; effecting better agricultural practices to prevent or minimize soil erosion and runoff; encouraging

strict adherence to instructions for handling and application; limiting usage of pesticides in relation to solubility, persistence, and toxicity; sponsoring research to ascertain toxic or lethal concentrations, synergistic and accumulative effects for all life forms of the aquatic system, and for wildlife and man; conducting research into environmental factors controlling dispersion of pesticides; encouraging research into the development of natural insect predators; research into the development of degradable pesticides less toxic to higher life forms; and requiring the manufacturer to supply information pertaining to persistence, toxic or lethal concentrations, and proper handling procedures before permitting sale of the pesticide.

IV-FWPCA ACTIVITIES

The Federal Water Pollution Control Administration, through the Great Lakes Regional Office, is pursuing a vigorous water pollution control program in the Great Lakes area in cooperation with the State and local agencies. The responsibilities of FWPCA were set forth by the Congress in the Federal Water Pollution Control Act, passed in 1956 and subsequently amended in 1961, 1965, and 1966. The following is a description of the activities being taken in carrying out the agency's responsibilities, with particular reference to those activities relevant to Lake Michigan and its drainage basin.

Interstate Enforcement Actions

Under the provisions of the Federal Water Pollution Control Act, two previous enforcement conferences have been held in the Lake Michigan Basin: the Menominee River conference, involving Michigan and Wisconsin, held on November 7, 1963; and the Calumet Area conference, involving Illinois and Indiana, held on March 2, 1965, with a technical session January 4, 1966, and sessions to report progress held on March 15, 1967, and September 6, 1967.

In the Menominee River conference, the findings were that interstate pollution did exist. The major problems in this area were paper mill wastes and municipal sewage. Recommendations were made to require more thorough waste treatment at three mills cited in the conference. Further waste treatment facilities were recommended for several communities on the river. Investigation was undertaken to determine whether remedial action would be required to alleviate the effects of gross iron pollution on the Brule River. The investigators found that no remedial action was needed.

In the Calumet conference, findings were that interstate pollution did exist, originating in both Illinois and Indiana, and that remedial action was needed. The conference recommended water quality criteria for the waters involved, secondary treatment and chlorination of all municipal waste discharged in the area, action by the States to ensure that industries minimize their wastes and a timetable for cleanup, provisions for sampling and surveillance, and closing the Thomas J. O'Brien locks on the Calumet River to prevent flow into the lake. The technical session held January 4-5, 1966, set the water quality criteria and the timetable for control of industrial waste discharges. On March 15, 1967, the conferees met and decided sufficient progress in pollution abatement was being made, and that the original timetable and recommendations remained satisfactory. Essentially, the same conclusions were reached at the progress meeting held September 6, 1967.

Water Quality Standards

Under provisions of the Water Quality Act of 1965, Indiana, Illinois, Wisconsin and Michigan adopted water quality standards for all of their interstate streams.

Standards are composed of two basin parts: the criteria that established quality levels that must be achieved to make water suitable for a designated use or uses; and the plans that specify what must be done, by whom and by what date to achieve the established water quality goals.

The Indiana standards have been approved by the Secretary of the Interior. Standards for the other three States are currently under review by the Secretary. Once the standards are accepted by the Secretary of the Interior, they become Federal standards as well as State standards.

As part of the adoption procedure, public hearings were held to elicit citizens' views on the proposed standards and to ascertain popular wishes as to the use of specific areas of lakes and streams. This action preceded formal State adoption of the standards.

Prior to submission to the Secretary, the standards for each State were reviewed by the Regional Office of FWPCA to determine whether they met the "Guidelines for Establishment of Water Quality Standards for Interstate Waters" of May 1966, as well as the intent of the Federal legislation. The review included a comparison of State standards and an attempt to resolve conflicts in water use and/or criteria between contiguous States.

Comments and suggestions relative to specific items in the standards were received from various agencies of the Interior Department as well as other Federal agencies.

Each submission included an overriding expression of intent to provide for the maintenance of the present high quality of interstate waters.

A copy of the complete set of each State standard is available to the public upon request to the appropriate State agency.

Great Lakes-Illinois River Basins Project

The Great Lakes-Illinois River Basins (GLIRB) Project was established in 1960 as a special task force in what is now the Federal Water Pollution Control Administration. With headquarters at Chicago, the Project was charged with developing comprehensive programs for eliminating or reducing the pollution of interstate waters and tributaries thereof, in the Great Lakes, the Illinois River, and their tributaries. In its early years the Project actually had two tasks, 1) the comprehensive program development and 2) to act in a fact-finding and consulting capacity to the U. S. Department of Justice in the Supreme Court litigation over diversion of Lake Michigan water at Chicago. The latter assignment had top priority and from 1961 to 1963, represented a large share of Project effort, culminating in the presentation of testimony and voluminous documentary exhibits, to the Special Master in Chancery appointed by the Court to

gather evidence and make his recommendations to the Court. It is believed that this work significantly influenced the subsequent settlement agreements reached in the case. (Principal points of the settlement agreement, as they affect water quality, are given in the next section.)

The major objectives of the comprehensive program developed by GLIRB Project in cooperation with other Federal agencies, with State water pollution control agencies and interstate agencies, and with the municipalities and industries involved were:

- Identification of the causes of water pollution and the effects of such pollution on the quality of water resources and on beneficial uses.

- The development of agreements on the desired beneficial uses and the water quality required to accommodate those uses.

- The development of water quality control measures to achieve the desired objectives, including the establishment of a timetable for their accomplishment.

- Provision of the mechanisms for carrying out program objectives, including continuing surveillance for the purpose of updating the programs to accommodate changing technology and changing water quality needs.

The Lake Michigan Diversion Case

A significant step toward preservation of Lake Michigan and the entire Great Lakes was realized when the Lake States agreed to the recommendations of the Special Master of the Supreme Court in the Chicago Diversion Case. The Special Master's recommendations are summarized as follows:

1. That the Metropolitan Sanitary District of Greater Chicago not be required to return its treated effluent to Lake Michigan.

2. That total diversion including pumpage be limited to the present 3,200 cubic feet per second and that diversion be averaged on a biennial rather than on an annual basis.

3. That the State of Illinois be given the responsibility for allocating the diversion.

4. That the most wise and effective use of the water be demonstrated before consideration is given in the future to requests for diversion. This will require improvements in the water supply distribution and waste collection and treatment practices.

The Special Master's report recognized the need to protect the waters of both Lake Michigan and the Illinois River. The first of the above recommendations was the most significant for the protection of the water quality of Lake Michigan.

Construction Grants

With the enactment of the Federal Water Pollution Control Act in 1956, the Federal government provided for a Federal sewage treatment works construction grants program to help finance the building of local sewage treatment plants. The Federal government recognized that wastes discharged from municipal sewers are one of the major causes of water pollution. The rapid growth of population and its continuous trend toward urban centers has resulted in a tremendous increase in the volume of such wastes.

Since 1956, 181 Federal grants have been awarded in the Lake Michigan Basin to help communities build sewage treatment facilities. Picture above is of the Grand Rapids, Michigan, sewage treatment plant.

Since the 1956 Act, a total of 181 Federal grants have been made in the Lake Michigan Basin to help communities build needed sewage treatment facilities. (See Figure 9) Grant funds involved in these projects have totaled over $22 million in support of total project expenditures in excess of $86 million. Over two-thirds of the 181 grant projects have already been completed and placed in operation. The remaining projects are either under construction or preparing to go under construction in the very near future.

The Construction Grants Section of the Federal Act has been amended three times since its initial 1956 passage. The trend of financial assistance has been upward each time the Act has been amended. Today's legislation allows municipalities to qualify for a basic Federal grant of 30 percent of the eligible cost of a project. A grant of 40 percent can be made in those States which agree to match the basic 30 percent Federal grant. The Federal grant may be increased to 50 percent if the State agrees to pay at least 25 percent of the project cost and enforceable water quality standards have been established for the waters into which the project discharges. A grant may be increased by 10 percent, to 33, 44, or 55 percent, as appropriate, if the project is certified by an appropriate metropolitan or regional planning agency as conforming with a comprehensive metropolitan area plan.

The States of Wisconsin and Indiana have enacted legislation to qualify their municipalities for consideration for the higher Federal grant percentages. The State of Illinois will place a bond issue to a referendum in November of 1968. A favorable vote on the referendum would entitle Illinois municipalities to consideration for higher Federal grants. The State of Michigan has considered State matching legislation to qualify its municipalities for higher Federal grants, but no legislation has yet been passed. Michigan currently has a State grant program that provides for local construction grants after the annual Federal construction grant allocation is exhausted, but the current Michigan grant program does not qualify its municipalities for the higher Federal grant levels.

Program Grants

Section 7 of the Water Pollution Control Act authorizes an appropriation of $10 million annually for Fiscal Years 1968-1971 for grants to State and interstate agencies to assist them in meeting the costs of establishing and maintaining adequate pollution control programs. Each State is allotted $12,000, and the remainder of the funds are distributed on the basis of population, financial need, and the extent of the water pollution problems facing the State. Since the program grants were instituted, a total of $5,673,440 in Federal funds has been allocated to the Lake Michigan States for their pollution control programs. By June 1968, Illinois will have received $2,119,976; Indiana, $1,188,919; Michigan, $1,284,673 and Wisconsin, $1,079,872.

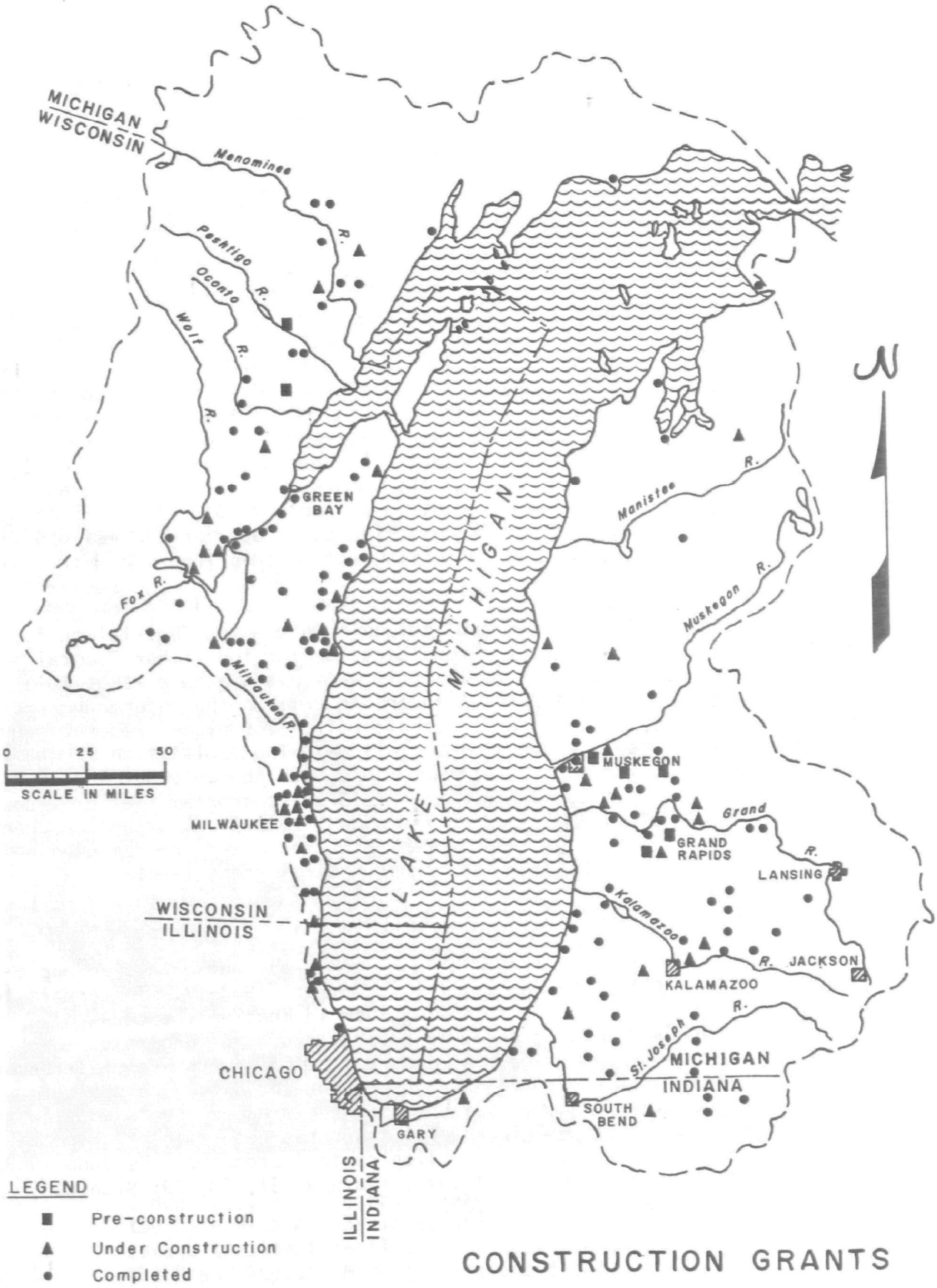

MICHIGAN
WISCONSIN
Menominee R.
Peshtigo R.
Oconto R.
Wolf R.
Fox R.
GREEN BAY
Milwaukee R.
MILWAUKEE
LAKE MICHIGAN
Manistee R.
Muskegon R.
MUSKEGON
Grand R.
GRAND RAPIDS
LANSING
Kalamazoo R.
KALAMAZOO
JACKSON
St. Joseph R.
SOUTH BEND
MICHIGAN
INDIANA
WISCONSIN
ILLINOIS
CHICAGO
GARY
ILLINOIS
INDIANA
0 25 50
SCALE IN MILES
N
LEGEND
Pre-construction
Under Construction
Completed
CONSTRUCTION GRANTS

FIGURE 9

Research and Demonstration

The Federal Water Pollution Control Act calls for establishing field laboratory and research facilities for the conduct of research, investigations, experiments, field demonstrations and studies, and training relating to the prevention and control of water pollution. The law also provides for granting fellowships and training grants to educational institutions, and grants or contracts to public and private agencies or individuals to demonstrate new or improved methods for dealing with water pollution problems.

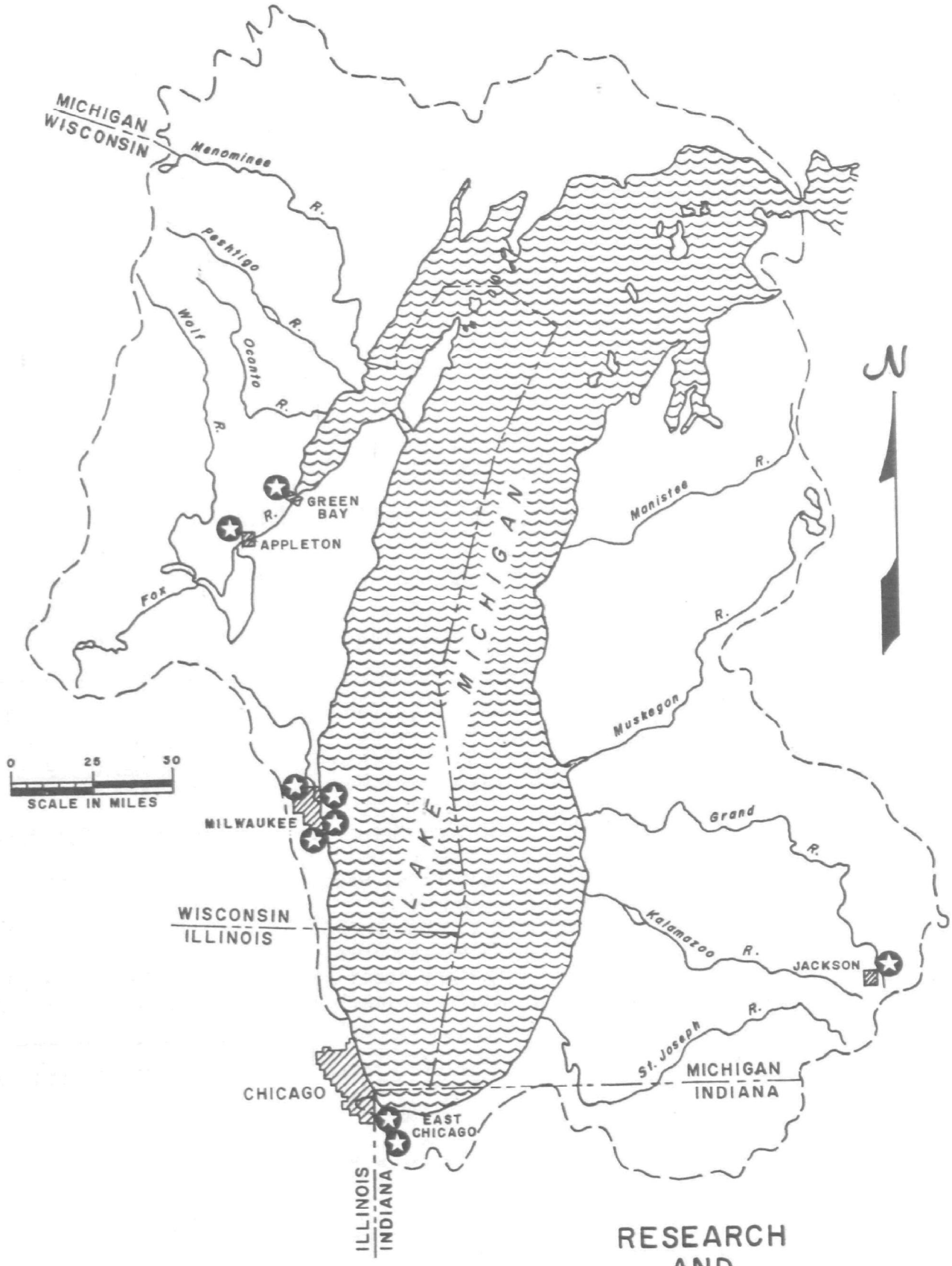
The Lake Michigan Basin has seven approved demonstration grants and two approved demonstration contracts in an active status. Applications for other possible grants are under review. Table 3 shows the present grants and contracts awarded, and Figure 10 shows locations.

TABLE 3

LAKE MICHIGAN BASIN R & D GRANTS & CONTRACTS

Location	Grant or Contract No.	Applicant	Federal Grant	Estimated Total Cost
E.Chicago,Ind.	11-IND-1	E.Chicago San. Dist.	$1,044,120	$3,116,533
E.Chicago,Ind.	WPRD 70-01-67	E.Chicago San. Dist.	450,000	600,000
Jackson,Mich	WPD-157	City of Jackson	11,919	11,919
Milwaukee,Wisc.	WPD 188-01-67	City of Milwaukee, Wisc.	95,578	95,578
Milwaukee,Wisc.	10-WIS-1	City of Milwaukee, Wisc.	1,468,589	2,118,118
Appleton,Wisc.	WPRD 12-01-68	Pulp Mfrs. Research League	483,371	690,530
Green Bay,Wisc.	WPRD 60-01-67	Green Bay Metro. Sewerage Dist.	251,250	335,000
*Milwaukee,Wisc.	14-12-40	Rex Chainbelt	197,989	197,989
*Milwaukee,Wisc.	14-12-24	Allis-Chalmers	388,526	388,526
		TOTAL	$4,391,342	$7,554,193

*Contracts



RESEARCH
AND
DEMONSTRATION GRANTS

FIGURE 10

Nature of Projects

11-IND-1 - Project will evaluate the effectiveness of treating combined sewer overflows in a very deep detention basin having aerobic and anaerobic levels of treatment.

WPRD 70-01-67 - The objective of this project is to develop and verify, on a small pilot scale, the preliminary design and operating conditions for chemical coagulation, sedimentation, dual media filtration, and granular activated carbon adsorption for treatment of combined municipal-industrial wastes mixed with storm run-off.

WPD 188-01-67 - A project to study phosphate removal by an activated sludge plant.

WPD-157 - Aeration of secondary effluent to further reduce BOD.

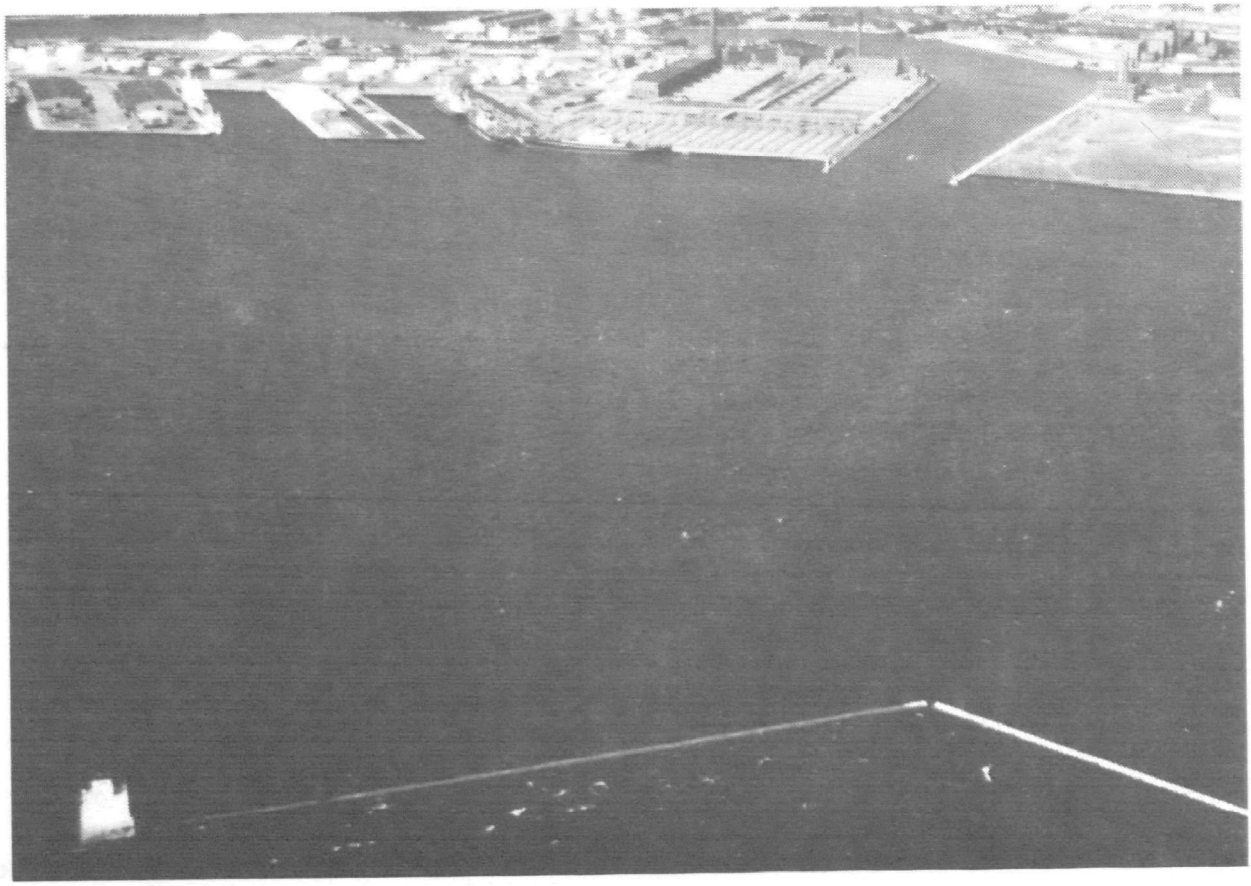
10-WIS-1 - Reduction of degree of pollution in the Milwaukee River is anticipated by increasing the efficiency of intercepting devices and by using a detention tank to capture and treat the storm overflow of combined sewage for an urban area comprising 570 acres which constitutes approximately 3 percent of the total combined sewers of the city. This includes the measurement of flows and quality at critical points within the collector system affecting the control of facilities to be constructed.

WPRD 12-01-68 - This project will demonstrate field scale, inplant treatment of dilute pulping wastes with a portable reverse osmosis unit. Development of in-plant techniques to reduce loadings on biological secondary treatment processing will be carried out. Project will accelerate development and evaluation of reverse osmosis as a method of concentrating dissolved solids in dilute wastes with recovery of clear water for reuse by the mill.

WPRD 60-01-67 - The project is a study, evaluation, and determination of the effectiveness, design, and operating parameters of four alternative biological treatment processes and modifications for treating combined municipal and industrial (primarily paper mill) wastewaters.

14-12-40 - This project will develop and demonstrate the applicaability of screening and chemical oxidation of storm and combined sewage.

14-12-24 - The primary purpose of the contract is to demonstrate the applicability of a new concept of biological treatment to be applied within a sewerage system.



Research is being conducted to reduce pollution of the Milwaukee River, shown here entering the Lake at its harbor mouth.

Wastes pour into Calumet Harbor on Lake Michigan
from U. S. Steel's Chicago South Works.

Present Status of Projects

Most projects are either in the construction phase or preconstruction phase of the grant or contract. WPD 188-01-67 will complete one year of study about the 1st of February 1968, on the phosphate removal from an activated sludge plant. One year of study is complete on WPD 157; report now awaited; study may be extended.

FWPCA research facilities in the Great Lakes Region provide a National Water Quality Laboratory at Duluth, Minnesota and a proposed laboratory at Ann Arbor, Michigan.

The National Water Quality Research Laboratory at Duluth, Minnesota is charged with the responsibility of developing water quality requirements for all fresh water uses in the United States.

The proposed research laboratory for Ann Arbor, Michigan will be involved in studies that will cover most all problems relating to water pollution and especially those problems in the Great Lakes area.

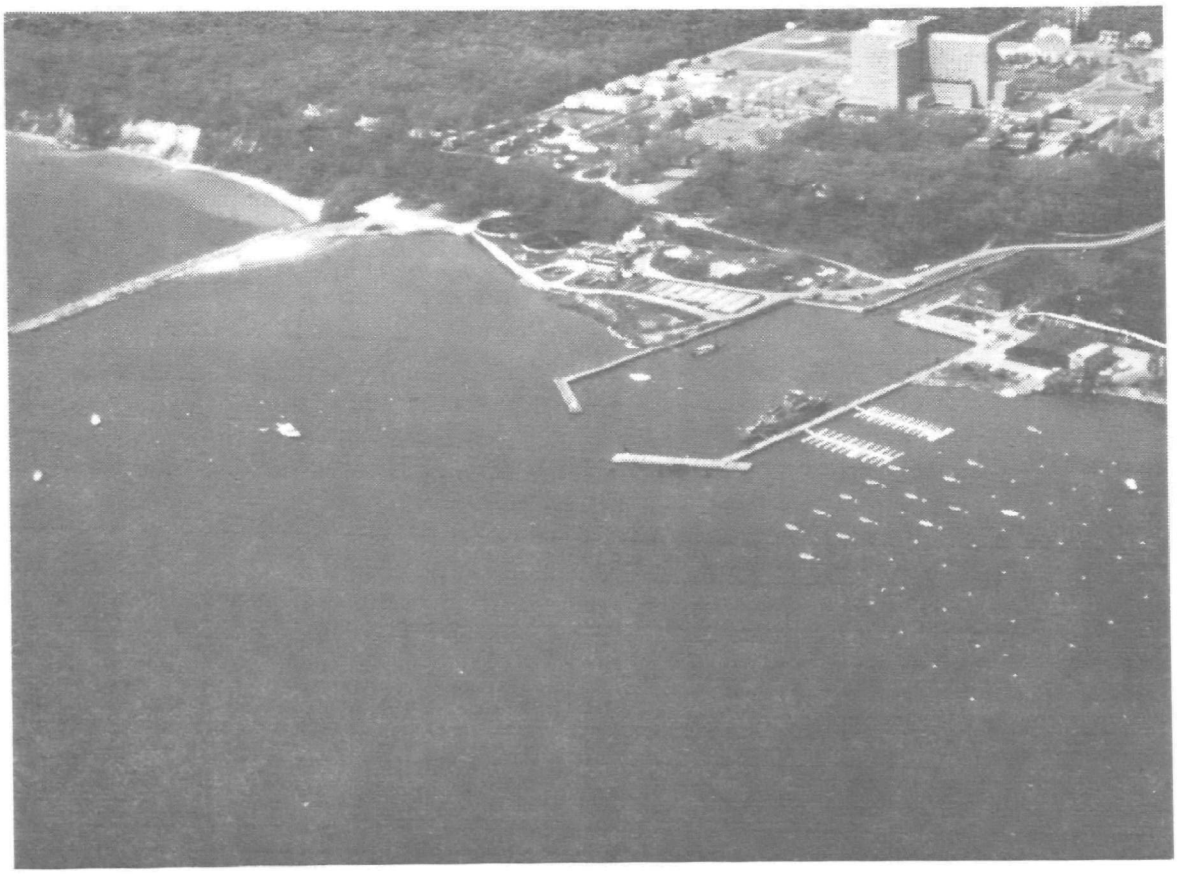
Federal Installations

The Federal Government has not overlooked the pollution hazards created by its own activities. By Executive Order 11288, President Johnson has directed the heads of the departments, agencies, and establishments of the Executive Branch of the Government to provide leadership in the nation-wide effort to improve water quality.

The Order directed all agencies to present annually a phased and orderly plan for needed corrective and preventive measures and facilities to the Bureau of the Budget to facilitate budgeting procedures. FWPCA has reviewed the plans submitted in an effort to achieve maximum pollution abatement. Project priorities have been established on the basis of the severity of the pollution problem with due regard for legitimate water uses, enforcement actions, and applicable water quality standards. Secondary treatment is the minimum acceptable under the Order for all projects. The establishment of water quality standards may necessitate higher degrees of treatment, including nutrient control, at some installations.

Federal installations in the Lake Michigan Basin have initiated pollution abatement programs in accordance with the Order. There are approximately 345 installations in the Basin, distributed as follows: Illinois, 12; Indiana, 34; Michigan, 171; and Wisconsin, 128. About 50 percent of these are connected to municipal sewer systems. The remaining 50 percent discharge wastes, after varying degrees of treatment, to ground or surface waters of the Basin. Some of the smaller installations provide no treatment at present. Tabulated in the Appendix of this report is an inventory of these installations showing the waste treatment provided and the status of pollution abatement.

Two installations account for three-fourths of all wastes generated by independently-discharging Federal sources in the Lake Michigan Basin.



Great Lakes Naval Training Center (pictured above) and Fort Sheridan account for more than half of all wastes contributed by independently-discharging Federal installations in the Lake Michigan Basin.

These are the Navy's Great Lakes Naval Training Center and the Army's Fort Sheridan. The sewer system at the Naval facility includes the training center, the command center for Ninth Naval District headquarters, and a Veterans Administration Hospital. Fort Sheridan is headquarters for the Fifth U.S. Army, recently relocated from the south side of Chicago. Waste treatment capability at both places is the conventional secondary type.

The more significant Federal vessels which frequent the waters and harbors of Lake Michigan are listed in the Appendix. The U.S. Coast Guard, Navy, and Army Corps of Engineers are all acutely aware of the problems associated with vessel pollution. They are actively pursuing abatement and research and development programs in an effort to obtain waste treatment devices suitable for ship board use.

The U.S. Coast Guard is installing a waste holding tank on the Cutter "Sundew" berthed at Charlevoix, Michigan. Wastes will be evacuated to the municipal sewer system. Other Coast Guard vessels have macerator/chlorinator units which are not considered adequate, and which will be corrected as rapidly as funds permit.

All Corps of Engineers' vessels and floating plants(tugs, dredges, derricks, etc.) operating in Lake Michigan, have been fitted with macerator/chlorinator units. Efforts are being made to insure that these devices will be replaced with acceptable treatment units or holding tanks at the earliest possible date. One dredge operating in Lake Erie is now being fitted with an extended aeration package plant of a type that is suitable for installation on all such floating plants.

The American Shipbuilding Company, Lorain, Ohio, has designed and is now installing secondary treatment plants on commercial cargo vessels under construction. Units of this type could be made adaptable for installation on Federal vessels.

Federal water resources projects and facilities and operations supported by Federal loans, grants, or contracts are also included in Executive Order 11288. Water resource projects must be designed, constructed, and operated in a manner which will reduce pollution from such activities to the lowest practicable level.

The head of each Federal department, agency, and establishment has been directed to conduct a review of the loan, grant, and contract practices of his own organization to determine to what extent water pollution control requirements set forth in the Order should be adhered to by borrowers, grantees, or contractors. This review has resulted in practices designed to reduce water pollution in various programs. Urban renewal projects now require the construction of separate storm and sanitary sewer systems rather than combined sewers. The nationwide highway construction program, financed with Federal funds and administered by the Bureau of Public Roads, is now being conducted in accordance with practices aimed at

preventing water pollution, either during construction or in operation and maintenance. The various agencies have consulted with the Federal Water Pollution Control Administration in an effort to insure maximum consideration of water quality in their activities.

This Order represents a major step forward in the battle to preserve and enhance the quality of our Nation's waters. It has sparked a keen awareness on the part of government officials of the need for corrective action and vigorous abatement programs. The effort being shown by these various Federal agencies provides leadership in the nationwide quality improvement program.

Technical Assistance

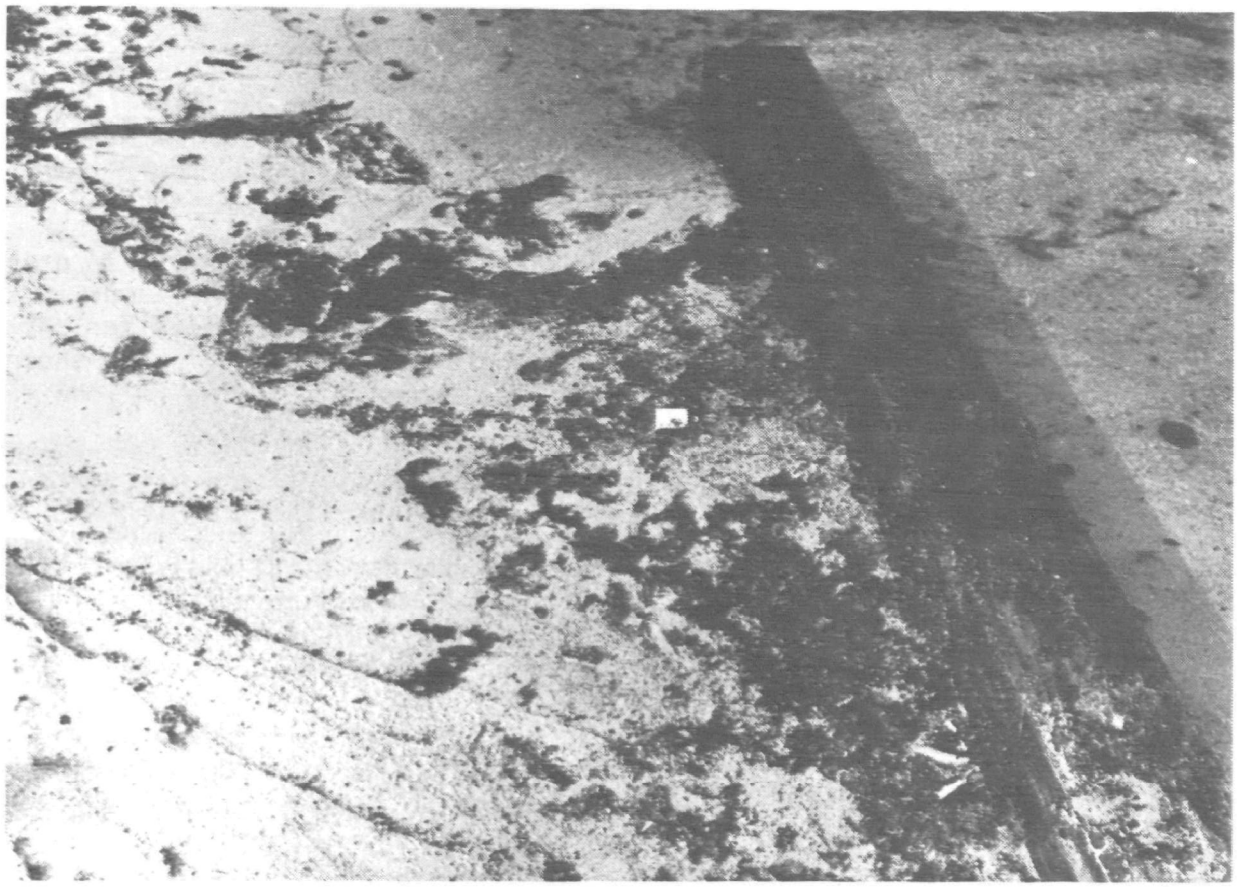
The Regional Technical Program provides technical assistance to States, local authorities, and industry upon request through the State water pollution control agencies, and to other Federal agencies. Current technical assistance projects in the Lake Michigan Basin include:

1. Participation in the Corps of Engineers' pilot program to develop practicable alternate methods for disposal of dredged material. This has involved collection and/or analyses of samples collected from 24 harbors on Lake Michigan.

2. Participation in the International Joint Commission study of the feasibility of further regulation of the levels of the Great Lakes, including Lake Michigan. The object of further lake regulation would be to reduce damages resulting from excessively high or low lake levels.

3. Investigation of character and source of oil pollution. In a recent incident which involved a large oil slick along the Chicago waterfront, an extensive investigation was made involving analyses of samples from 18 beaches and 10 lake stations. The type of oil was identified, and although this information eliminated several possible sources, the actual source was not determined.

The Technical Program also has responsibility for maintaining water quality surveillance through stations in the National Water Pollution Surveillance System. Lake Michigan stations located at Milwaukee, Wisconsin and Gary, Indiana, provide long-term records of water quality characteristics which provide highly important indications of water quality trends. The Program is also providing surveillance of water quality conditions in the Calumet enforcement area, to determine status of compliance with conference recommendations. This operation has included weekly collection and analyses of samples from Indiana Harbor Canal and Lake Michigan, operation of two automatic water quality monitors, and bi-weekly sampling of beaches during the swimming season.



Part of the residue of a 75-mile long oil slick that stretched along the Chicago water front last summer is shown on the beach. (Photo courtesy of the Chicago Tribune.)

Public Information

The Public Information Program of the Federal Water Pollution Control Administration is designed to present facts about water pollution control to the news media, interested groups and organizations, and the public, generally. The Program serves the public's right to know what FWPCA is doing and trying to accomplish. It also serves those who need particular information in order to participate effectively in water pollution control programs.

V-CONCLUSIONS

1. Lake Michigan is a priceless natural heritage which the present generation holds in trust for posterity, with an obligation to pass it on in the best possible condition.

2. Water uses of Lake Michigan and its tributaries for municipal water supply, recreation, including swimming, boating, and other body contact sports, commercial fishery, propagation of fish and aquatic life, and esthetic enjoyment, are presently impaired by pollution in many parts of all four of the States that border upon and have common boundaries within the Lake. The sources of this pollution include wastes from municipalities, industries, Federal activities, combined sewer overflows, agricultural practices, watercraft, natural runoff, and related activities throughout the drainage basin.

3. Eutrophication is a threat now to the usefulness of Lake Michigan and other lakes within the Basin. Unless checked, the aging of Lake Michigan will be accelerated by continuing pollution to the extent that it will duplicate the Lake Erie eutrophication condition. Feasible methods exist for bringing this problem under control. They need to be applied.

4. Evidence of severe bacterial pollution of tributaries has been found in the Fox River between Lake Winnebago and Green Bay, Wisconsin; the Milwaukee River within Milwaukee County, Wisconsin; in and downstream from the cities along the Grand River in Michigan and the St. Joseph River in Indiana and Michigan; and the streams of the Calumet Area, Illinois and Indiana. Although the bacterial quality of Lake Michigan is generally good in deep water, the water is degraded along the shoreline and in harbor areas.

5. Pollution has contributed to the growth of excessive inshore algal populations which have occurred in the vicinity of Manitowoc to Port Washington, Wisconsin; Chicago, Illinois; the entire eastern shore of Lake Michigan, and near Manistique, Michigan. Short filter runs in water treatment plants have occurred at Green Bay, Sheboygan, and Milwaukee, Wisconsin; Waukegan, Evanston, and Chicago, Illinois; Gary, Michigan City and Benton Harbor, Indiana; and Holland, Grand Rapids, and Muskegon, Michigan. Phosphate fertilizer concentrations now exceed critical algal growth values in many areas. Excessive sludgeworm populations indicating pollution of lake bed sediments occur near Manitowoc; Sheboygan; Port Washington, Wisconsin to Waukegan, Illinois; and Chicago, Illinois to Muskegon, Michigan.

6. The small quantity of oxygen normally dissolved in water is perhaps the most important single ingredient necessary for a healthy, balanced, aquatic life environment. The discharge of treated and untreated municipal and industrial wastes with their high concentrations of biochemical oxygen demand have caused oxygen depletion in many of the

Lake Michigan tributaries and in some harbors. At present the main body of Lake Michigan has not evidenced signs of oxygen deficiency.

7. In addition to one existing nuclear power plant, five nuclear power plants, three of which will have twin reactors, are proposed or under construction at Lake Michigan cities for completion between 1970 and 1973. A special evaluation of the combined impact of siting many reactors on the shores of the Lake, in relation to retention and flushing characteristics and to accumulation of radionuclides in aquatic organisms, is desirable.

8. Vessels of all types, commercial, recreational, and Federal, plying the waters of Lake Michigan and its tributaries are contributors of both untreated and inadequately treated wastes in local harbors and in the open lake, and intensify local problems of bacterial pollution.

9. Oil discharges from industrial plants and commercial ships, and careless loading and unloading of cargos, despoil beaches and other recreational areas, contribute to taste and odor problems and treatment problems at water treatment plants, coat the hulls of pleasure boats, any may be toxic to fish and other aquatic life.

10. Disposal of polluted dredged material in Lake Michigan open water causes discoloration, increased turbidity, and oil slicks. Additionally, the pollutants contained in dredged material also contribute to increased concentrations of dissolved solids, nutrients, and toxic material, which are responsible for deterioration of water quality.

11. Pesticide pollution of Lake Michigan and its tributary streams results from the application of these materials by spraying and dusting. Pesticides are used most heavily in the Lake Michigan Drainage Basin in areas of extensive fruit, grain, and vegetable growing, dairying, and general farming. These areas are: The Wisconsin portion of the Green Bay watershed; the Milwaukee area; the southeast quadrant of the Basin, including the St. Joseph and Grand River Basins; and the Traverse Bay area. The ever-increasing use of these materials threatens water uses for recreation, fish and wildlife, and water supplies.

12. A contaminant entering directly into Lake Michigan, or dissolved in the water that feeds the Lake, mixes with and eventually becomes an integral part of the Lake water as a whole -- regardless of the point of origin around the periphery or on the contributing watershed.

13. Discharges of untreated and inadequately treated wastes originating in Wisconsin, Illinois, Indiana, and Michigan cause pollution of Lake Michigan which endangers the health or welfare of persons in States other than those in which such discharges originate. This pollution is subject to abatement under the provisions of the Federal Water Pollution Control Act, as amended (33 U.S.C. 466 et seq.)

VI - RECOMMENDED ACTIONS

GENERAL RECOMMENDATIONS

It is recommended that:

1. Advanced waste treatment, beyond secondary, be provided in the places hereinafter named and elsewhere to the extent necessary to maintain water quality standards.

2. Where a higher degree is not required, all other municipal wastes be given at least secondary (biological) treatment; facilities to be efficiently and continuously operated to achieve an overall removal of at least 90 percent of the biochemical oxygen demand and at least 80 percent of phosphates.

3. Continuous effective disinfection be provided throughout the year for all municipal waste treatment plant effluents.

4. Organic wastes and sanitary sewage discharged by industries receive the same treatment as recommended for municipal wastes in the above four recommendations.

5. Action be taken toward the exclusion or maximum treatment of all industrial wastes contributing to pollution; and that industrial wastes be discharged to municipal sewer systems where at all possible.

6. Wastes from Federal activities be treated to degrees at least as good as that recommended for other sources.

7. Combined sewers be prohibited in all newly developed urban areas and separated in coordination with all urban reconstruction projects.

8. Overflow regulating devices of combined sewer systems be designed and operated in such manner as to convey the maximum practicable amount of combined flow to treatment facilities.

9. Agricultural practices be improved to ensure the maximum protection of the waters of the Lake Michigan Basin from the application of fertilizers and pesticides.

10. State water pollution control agencies obtain and maintain accurate records of quantities of pesticides utilized on a county basis.

11. State water pollution control agencies maintain surveillance of pesticides, including determination of pesticide content in the aquatic environment and initiation of corrective action where needed.

12. Waste heat discharges be reduced where other water uses are adversely affected; and that the quality requirements of the receiving waters be a prime factor in selecting location and method of heat dissipation used for any new installations requiring large amounts of cooling water.

13. The radioactive discharges from nuclear power plants be so controlled as to protect the environment; all interested agencies must coordinate their efforts in a careful study of the effects of siting many reactors on the shores of Lake Michigan, and acceptability of radioactive waste discharges must be based on the combined impact of all sources on the Lake.

14. A special investigation be made of the effects which the installation of large power plants, both fossil-fueled and nuclear, have on Lake Michigan; this investigation to include studies of benthic fauna, radioactivity, water temperature, heat diffusion and lake currents.

15. As a matter of policy, planning provide for the maximum use of areawide sewerage facilities, discourage the proliferation of small inefficient treatment plants in contiguous urbanized areas, and foster the elimination of septic tanks.

16. Uniform lakewide State laws or local legislation be enacted to provide the same degree of control over the discharge of wastes from watercraft as is now provided by the Chicago city code.

17. All marinas or other facilities servicing watercraft be required to make provisions for the receipt, treatment, and onshore disposal of the wastes from vessel holding tanks.

18. The discharge of oil from any source into any waters of the Lake Michigan Basin be stopped entirely.

19. State water pollution control agencies compile an inventory of all sites where potential exists for major spills of oil and other hazardous material; and require that measures be taken where necessary to prevent the escape of this material to the waters.

20. The appropriate State and Federal agencies jointly develop an early warning system to deal with accidental spills of oil and other hazardous material.

21. Disposal into Lake Michigan Basin waters of polluted dredgings be prohibited.

22. Monthly reports covering the operation of all municipal and industrial waste treatment plants, including the quality and quantity of effluent, be submitted to the appropriate agencies for review,

evaluation, and appropriate action; and that water pollution control agencies conduct inspections of all waste treatment plants at least quarterly.

23. The water quality monitoring programs of the State agencies of the Lake Michigan Basin be strengthened, and programs geared to indicate change or trends in water quality and the need for additional quality improvement measures.

24. The operation of all facilities affecting streamflow, such as hydroelectric plants, be regulated to ensure the availability of optimum streamflow for all legitimate uses.

25. Research on pressing problems of the Lake Michigan Basin be vigorously pursued. Principal areas in which research is needed included: control of over-production of algae; more effective and less costly methods for removing dissolved chemicals, especially nutrients, from wastewaters; techniques for restoring eutrophic lakes; methods for ultimate disposal of residues removed from wastewaters; improved treatment and other measures for handling industrial wastes particularly of the paper and steel industries; permanent solutions for combined sewer problems; effective treatment plants for ships; improved standardization of water quality tests; and improved techniques for water quality monitoring.

SPECIFIC RECOMMENDATIONS

The following specific recommendations are made for the municipalities and industries listed below.

CODE:
1. Provide adequate secondary biological treatment or its equivalent and advanced waste treatment for phosphate removal and substantial reduction of nutrients which result in undesirable aquatic growths by July 1972.
2. Provide advanced waste treatment for phosphate removal and substantial reduction of nutrients which result in undesirable aquatic growths by July 1972.
3. Substantially eliminate pollution from combined sewers by July 1977.

ILLINOIS

Municipality	Code
Highland Park	2
Lake Bluff	2
Lake Forest	2
North Chicago	1,3
Waukegan	1,3

Waste treatment needs for the following industries to be determined within six months of the issuance of the conference summary and construction of necessary facilities to be completed within 36 months.

Industry	Location
Abbott Laboratories	North Chicago
Outboard Marine Corp.	Waukegan
U. S. Steel Corp., American Steel and Wire	Waukegan
Bulk Terminals*	Chicago
Interlake Steel Corp.*	Chicago
Wisconsin Steel Corp.*	Chicago
Republic Steel Co.*	Chicago
U. S. Steel Corp., South Works*	Chicago

*To comply with recommendations and schedule of the Lake Michigan-Calumet Area Conference.

INDIANA

Municipality	Code
Angola	1,3
Elkhart	1,3
Goshen	3
Kendallville	1,3
Mishawaka	1,3
South Bend	1,3
Hammond	1,3
East Chicago	2,3
Gary	2,3
Michigan City	1,3

Waste treatment needs for the following industries to be determined within six months of the issuance of the conference summary and construction of necessary facilities to be completed within 36 months.

Industry	Location
Weatherhead Co.	Angola
Bristol Band Instrument Co.	Bristol
Continental Can Co.	Elkhart
Elkhart Packing Co.	Elkhart
McCray Refrigerator Co.	Kendallville
Price Duck Farms	Milford
Slabaugh Duck Farms	Milford
Bendix Corp.	South Bend

NOTE: All industries in the Lake Michigan-Calumet enforcement area are to comply with the recommendations of that conference summary.

MICHIGAN

Municipality	Code
Menominee	1,3
Iron Mountain	1,3
Escanaba	2
Gladstone	1,3
Manistique	1,3
Petoskey	1
Traverse City	1,3
Manistee	1,3
Ludington	1,3
Muskegon Heights	2
Muskegon	1,3
Big Rapids	1,3
Cadillac	2
Grand Haven	1,3
Delhi Township	1
East Lansing	2,3
Grand Ledge	1,3
Grand Rapids	2,3
Jackson	2,3
St. Johns	2,3
Jackson Prison	2
Lansing	2,3
Wyoming	2
Portage	2
Battle Creek	2
Charlotte	2
Allegan	1,3
Otsego	2
Plainwell	2
Kalamazoo	2
Benton Harbor	2
Buchanan	1
Niles	1,3
Dowagiac	1,3
Three Rivers	1,3
Sturgis	2
Coldwater	2
Hillsdale	2

Waste treatment needs for the following industries to be determined within six months of the issuance of the conference summary and construction of necessary facilities to be completed within 36 months.

Industry	Location
Inland Steel Co.	Iron River
American Can Co.	Menominee
Menominee Mill	Menominee

Industry	Location
Alberta Canning Co.	Alberta
Manistique Pulp & Paper Co.	Manistique
Lead Corp.	Escanaba
Escanaba Div.	Escanaba
Petoskey Plating Co.	Petoskey
Consumers Power Co.	Big Rock Point
East Jordan Canning Co.	East Jordan
Howes Leather Co., Inc.	Boyne City
Cherry Growers, Inc.	Grawn
Traverse City Canning Co.	Traverse City
Morgan-McCool, Inc.	Traverse City
Elk Rapids Packing	Leelanau
Northport Cherry Factory	Northport
Frigid Foods, Inc.	Suttons Bay
Crystal Canning Co.	Frankfort
Meltzer Packing Co.	Benzonia
Alberta Canning Co.	Alberta
Packaging Corp. of America	Filter City
Great Lakes Chemical Corp.	Filter City
Michigan Chemical Corp.	East Lake
Morton Salt Co.	Manistee
Manistee Salt Co.	Manistee
Stokely Van Camp, Inc.	Scottville
Dow Chemical Co.	Ludington
Hart Cherry Packers	Hart
Stokely Van Camp, Inc.	Hart
New Era Canning Co.	New Era
Whitehall Leather Co.	Whitehall
E. I. Du pont Co.	Montague
Hooker Chemical Co.	Montague
Gerber Products	Fremont
Lakeway Chemicals, Inc.	Muskegon
Continental Motors Corp.	Muskegon
Naph-Sol Refining Co.	North Muskegon
S. D. Warren Co.	Muskegon
Keeler Brass Co.	Middleville
Attwood Corp.	Lowell
Crystal Refinery	Carson County
Jervis Corp.	Grand Haven
Eagle Ottawa Leather Co.	Grand Haven
Packaging Corp. of America	Grand Rapids
Wolverine World-wide	Rockford
Mead-Johnson Co.	Zeeland
Parke-Davis Co.	Holland
Michigan Fruit Canners, Inc.	South Haven
Kalamazoo Paper Co.	Kalamazoo
Brown Paper Co. KVP #1 Parchment and Wax Paper	Parchment
Brown Paper Co. Sutherland Div. #1 Paperboard	Kalamazoo

Industry	Location
Brown Paper Co. KVP #4 & 7 Paperboard Prod.	Kalamazoo
Brown Paper Co. DVP #2	Parchment
National Gypsum Co.	Kalamazoo
Hawthorne Paper Co.	Kalamazoo
Allied Paper Co., King Div.	Kalamazoo
Allied Paper Co., Monarch Div.	Kalamazoo
Allied Paper Co., Bryant Div.	Kalamazoo
Upjohn Company	Kalamazoo
MacSim Bar Paper Co.	Otsego
Murray Packing Co.	Plainwell
Otsego Falls Paper Mills, Inc.	Otsego
Watervliet Paper Co.	Watervliet
Welch Grape Juice Co.	Lawton
Simpson Lee Paper Co.	Vicksburg
Weyerhauser Paper Co.	White Pigeon
Clark Equipment Co.	Buchanan

WISCONSIN

Municipality	Code
Shawano	1,3
New London	1,3
Clintonville	1
Green Bay	1,3
De Pere	1,3
Little Chute	2,3
Kimberly	2
Kaukauna	1,3
Appleton	2,3
Neenah-Menasha	1,3
Portage	2
Berlin	2,3
Oshkosh	1,3
Ripon	2
Fon du Lac	2
Port Washington	1,3
Menominee Falls	1
Milwaukee	
Jones Island	2,3
South Shore	1,3
South Milwaukee	1,3
Carrollville	1
Kenosha	1,3
Racine	1,3
Oconto	1,3
Sturgeon Bay	2,3
Marinette	1,3
Greendale	1
Hales Corners	2
Two Rivers	1,3

Municipality	Code
Sheboygan	1,3
Sheboygan Falls	2
Plymouth	1
Manitowoc	1,3
West Bend	1

Waste treatment needs for the following industries to be determined within six months of the issuance of the conference summary and construction of necessary facilities to be completed within 36 months.

Industry	Location
Green Bay Packaging	Green Bay
Charmin Paper Co.	Green Bay
Marathon Paper Co.	Green Bay
Fort Howard Paper Co.	Green Bay
U. S. Paper Mills Corps.	De Pere
Nicolet Paper Co.	De Pere
Charmin-Little Rapids	Little Rapids
Thilmany Paper Co.	Kaukauna
Combined Locks Paper Co.	Combined Locks
Kimberly Clark Co.	Kimberly
Consolidated Paper Co.	Appleton
Riverside Paper Co.	Appleton
Fox River Paper Co.	Appleton
Whiting Paper Co.	Menasha
Marathon Paper Co.	Menasha
John Strange Paper Co.	Menasha
Gilbert Paper Co.	Menasha
Kimberly Clark Co.	Neenah
Bergstrom Paper Co.	Neenah
Kimberly Clark Co. (Badger-Globe)	Neenah
Kimberly Clark Co. (Neenah Div.)	Neenah
Scott Paper Co.	Oconto Falls
Badger Paper Mills	Peshtigo
Scott Paper Co.	Marinette
Kimberly Clark	Niagara
Peter Cooper Corp.	South Milwaukee
American Motors	Kenosha
Anaconda American Brass	Kenosha
Shepard Plating Co.	Racine
C & D Duck Co.	Franksville
York Duck Co.	Franksville
J. I. Case	Racine

FEDERAL INSTALLATIONS

Facility	Code
Great Lakes Naval Training Sta.	2
Fort Sheridan	2
K. I. Sawyer Air Force Base	2

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APPENDIX

APPENDIX A

STATUS OF WASTE TREATMENT AT FEDERAL INSTALLATIONS LOCATED IN THE LAKE MICHIGAN DRAINAGE BASIN

Installation (Name & Location)	Volume & type of wastes (1,000 GPD)	Receiving Waters	Treatment Provided	Rating	Remarks
ILLINOIS					
U.S. Coast Guard					
1. South Chicago Station Chicago (Cook Co.) (Calumet Harbor)	1.5 S	G	ST, DF	A	
2. Chicago Harbor Station Chicago (Cook Co.)	2.0 S	Chicago Harbor (L.Mich.)	ST	B	Plans for package secondary S.T.P. prepared
3. Calumet Harbor Light Sta. (Cook Co.)	0 Previous discharge of raw waste to Calumet Harbor abated by recent station automation				
U.S. Navy					
4. Great Lakes Naval Training Center Great Lakes (Lake County)	3,500. S	Lk.Michigan	Sec. Cl_2 (96% BOD & 78% S.S. removal)	B	Plant enlargements programmed for FY 1969; Navy has also initiated planning to remove wastes from basin and to treat water treatment plant backwash. See text.
5. Naval Reserve Training Center (Armory) Chicago (Cook Co.)	8.8 S	Chicago Harbor	Primary (ST, Cl_2)	B	Armory is owned by the State of Illinois

LEGEND: Treatment Provided; ST - Septic Tank; DF - Drain Field; Sec. - Secondary Treatment; Cl_2 - Chlorination.

Ratings; A - adequate; B - inadequate, abatement program progressing; C - in compliance with Lake Michigan-Calumet Enforcement Conference Recommendations; D - inadequate, no action taken.

Others; S - Sanitary; I - Industrial; G - Ground.

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Installation (Name & Location)	Volume & type of wastes (1,000 GPD)	Receiving Waters	Treatment Provided	Rating	Remarks
ILLINOIS, Cont'd.					
U.S. Army					
6. Ft.Sheridan, Ft.Sheridan (Lake County)	1,500. S	Lake Michigan	Sec., Cl_2	B	See text
	?	L.Mich.	None	B	Water treatment plant filter backwash.
Veterans Administration					
7. Veterans Administration Hospital, Downey (Lake County)	(350. S)		Wastes discharged to Great Lakes Naval Training Center sewer system		
INDIANA					
U.S. Coast Guard					
8. Michigan City Station Michigan City (LaPorte Co.)	1.0 S	G	ST, DF	B	A connection to the Michigan City sewer system is planned.
9. Indiana Harbor East Bkw.Lt. Sta., East Chicago (Lake Co.)	0.45 S	Lake Mich. (Indiana Harbor)	Sec., Cl_2 (95% BOD & S.S. reduction)	A, C	Experimental package S.T.P. recently evaluated for adequacy by FWPCA
U.S. Navy					
10. Reserve Training Center Gary (Lake Co.)	0.9 S	G	ST, DF	A, C	Sandy soil in area of tile field
U.S. Army					
11. Nike C.G. Site 32 Chesterton (Porter Co.)	6-8.0 S	Dunas Cr.-Lt.Calumet River	Sec., Cl_2	A, C	Imhoff tank sand filters, chlorine contact tank

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Installation (Name & Location)	Volume & type of wastes (1,000 GPD)	Receiving Waters	Treatment Provided	Rating	Remarks
INDIANA, Cont'd.					
U.S. Army					
12. Nike C.G. Site 45 Gary (Lake Co.)	3.0 S	Unnamed Ditch trib. to Grand Calumet R.	Sec., Cl_2	A, C	Septic tank, built-up subsurface sand filter, chlorine contact tank
13. Nike C.G. Site 47 Wheeler (Porter Co.)	6-8.0 S	Unnamed Ditch trib. to Burns Ditch	Sec., Cl_2	A, C	Imhoff tank, intermittent sand filters, chlorine contact tank
General Services Administration					
14. Defense Material Service Depot, Hammond (Lake Co.)	0.9 S 100.0 I	Ground Wolf Lake	ST, DF None	A, C A, C	Cooling water from air conditioning & dehumidification equipment
Federal Aviation Agency					
15. Air Route Traffic Control Center, LaGrange (LaGrange Co.)	0.2 S	G	ST, DF	A	
Post Office Department					
16. P.O., Middlebury (Elkhart Co.)	0.1 S	G	ST, DF	A	

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Installation (Name & Location)	Volume & type of wastes (1,000 GPD)	Receiving Waters	Treatment Provided	Rating	Remarks
MICHIGAN					
U.S. Army					
17. National Guard Facility Grand Rapids (Kent Co.)	3.0 S	G	ST, DF		
18. U.S.Army Military Engine Plant, Muskegon (Muskegon Co.)	30.0 I	G	Chem.Treatment to stabilize metallic wastes & oil	(A)	Treated wastes discharged to holding lagoon; high chromate and cyanide concentrations in wastes infiltrate to ground: adequacy being evaluated.
19. Grand Haven Boatyard Grand Haven (Ottawa Co.)	0.2 S	Grand River	ST, Cl_2	D	Recommendation made by FWPCA to connect to city sewer.
U.S. Navy					
20. Reserve Training Center Battle Creek (Calhoun Co.)	0.29 S	G	ST, DF		
U.S. Air Force					
21. Empire AFS, Empire (Leelanau Co.)	18.0 S	G	ST, DF		Adequacy unknown
22. K.I.Sawyer AFB Republic (Marquette Co.)	469.0 S	Silver Lead Cr.	Sec.	B	Plans for upgraded facilities completed and approved.
	0.5 S	G	ST, DF	A	

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Installation (Name & Location)	Volume & type of wastes (1,000 GPD)	Receiving Waters	Treatment Provided	Rating	Remarks
MICHIGAN, Cont'd.					
U.S. Coast Guard					
(23.) Frankfort Station, Frankfort (Bay Co.)	2.1 S	(G)	(ST, DF)	A	To city sewer
24. Pointe Betsie Light Station, Pointe Betsie (Benzie Co.)	1.2 S	G	ST, DF	A	New system installed 1965: condition - good.
25. Beaver Island Station Beaver Island (Charlevoix Co.)	0.5 S	G	ST, DF		Condition of DF - Unknown
26. St.Martin Island Light Station (Delta Co.)	0.35 S	G	ST, DF		Condition of DF - Unknown
27. Minneapolis Shoal Lt. Sta., Escanaba (Menominee Co.)	0.4S	Green Bay	None		*
28. Grays Reef Light Station, Cross Village (Emmet Co.)	0.35 S	Lake Michigan	None	B	*
29. White Shoal Light Station, (Emmet Co.)	0.5 S	Lake Michigan	None	B	*
30. North Manitou Shoal Light Station, (Leelanau Co.)	0.35 S	Lake Michigan	None	B	*

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Installation (Name & Location)	Volume & type of wastes (1,000 GPD)	Receiving Waters	Treatment Provided	Rating	Remarks
MICHIGAN, Cont'd.					
31. Grand Traverse Lt.Station, Northport (Leelanau Co.)	0.8 S	G	ST, DF	A	
32. Big Sable Light Station, Ludington (Mason Co.)	1.0 S	G	ST, DF	A	
33. Lansing Shoal Light Station (Mackinac Co.)	0.35 S	Lake Michigan	None	B	*
34. Grand Haven Station, Grand Haven (Ottawa Co.)	3.0 S	G	ST, DF	B	DF too near water
35. Holland Moorings, Holland, (Ottawa Co.)	0.9 S	G	ST, DF	A	Condition of DF - good; installed 1964
36. Seul Choix Pointe Light Station (Schoolcraft Co.)	1.0 S	G	ST, DF	A	
(23) Menominee Pierhead Lt.Sta.	0.2 S	Green Bay	None	B	*
Menominee(Menominee Co.)	0.7 S	City Sewer		A	

* The Coast Guard has initiated a program to unman and automate all light stations in the Great Lakes as rapidly as funds are available.

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Installation (Name & Location)	Volume & type of wastes (1,000 GPD)	Receiving Waters	Treatment Provided	Rating	Remarks
MICHIGAN. Cont'd.					
Federal Communications Commission					
37. Monitoring Station, Allegan (Allegan County)	0.12 S	G	ST, DF		
Bureau of Sports Fisheries and Wildlife					
38. Charlevoix Nat. Fish Hatchery, Charlevoix (Charlevoix County)	800. I	Lake Michigan	None	A	Overflow from hatchery
39. Seney National Wildlife Refuge Headquarters (Schoolcraft County)	1.0 S	G	None	D	Pit toilets
Dept. of Agriculture - Forest Service					
Hiawatha National Forest					
40-53 Alger, Delta, Mackinac (Schoolcraft Counties) 14 campgrounds with 254 camping units and 92 picnic units	302 P -S	G	None		Pit toilets
54. Lake Michigan Campground (Mackinac Co.) (18 C, 18 P)	3.0 S	G	ST, DF		

APPENDIX A

STATUS OF WASTE TREATMENT AT FEDERAL INSTALLATIONS LOCATED IN THE LAKE MICHIGAN DRAINAGE BASIN

Installation (Name & Location)	Volume & type of wastes (1,000 GPD)	Receiving Waters	Treatment Provided	Rating	Remarks
MICHIGAN, Cont'd.					
Hiawatha National Forest					
55. Brevoort Lake Campground (Mackinac Co.) (70 C, 8 P)	5.0 S	G	ST, DF		
56. Clear Lake Organization Camp (Schoolcraft Co.)	0.8 S	G	ST, DF		
57. Thunder Bowl Winter Sports Area (Schoolcraft Co.)					
58. Rapid River Administration Area (Delta Co.)	0.5 S	G	ST, DF		
Manistee National Forest					
59-62. 4 Campgrounds (Lake County)	110 P - S	G	None		Pit toilets
63. District Ranger Headquarters, Baldwin (Lake Co.)	0.8 S	G	ST, DF		
64. Hemlock Campground, Cadillac (Wexford Co.)	30 P - S	G	None		Pit toilets
65-67. 3 Campgrounds (Wexford Co.)	200 P - S	G	None		Pit toilets

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STATUS OF WASTE TREATMENT AT FEDERAL INSTALLATIONS LOCATED IN THE LAKE MICHIGAN DRAINAGE BASIN

Installation (Name & Location)	Volume & type of wastes (1,000 GPD)	Receiving Waters	Treatment Provided	Rating	Remarks
MICHIGAN, Cont'd.					
Manistee National Forest					
68. Harrietta Gd. Dwelling, Harrietta (Wexford Co.)	0.2 S	G	ST, DF		
69. Caberfae Winter Sports Area, Harrietta (Wexford Co.)	12.2 S	G	ST, DF		
70-71. 2 Campgrounds (Manistee Co.)	65 P - S	G	None		Pit toilets
72. Housing & Shop, 3 units (Manistee Co.)	0.6 S	G	ST, DF		
73. Manikewa Organization Camp (Manistee Co.)	5.2 S	G	ST, DF		
74. River Drive Picnic Ground (Mason Co.)	15 P - S	G	None		Pit toilets
75. Lake Michigan Rec. Area (Mason Co.)	18.0 - S	G	ST, DF		Newly developed. Not all in service.
76. Pines Point Campground (Oceana Co.)	20 P - S	G	None		Pit toilets
77. Wayside Lake Picnic Grounds, Whitecloud (Newaygo Co.)	0.7 S	G	ST, DF		

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Installation (Name & Location)	Volume & type of wastes (1,000 GPD)	Receiving Waters	Treatment Provided	Rat-ing	Remarks
MICHIGAN, Cont'd.					
Manistee National Forest					
78. 1 Campground & 1 Picnic Ground (Newaygo Co.)	0.5 S	G	None		Pit toilets
Ottawa National Forest					
79. Nesbit Lake Organization Camp (Iron Co.)	1.0 S	G	ST, DF		
80. Ottawa Lake Campground (Iron Co.)	2.0 S	G	ST, DF		
81-82. 2 Campgrounds (Iron Co.)	180 P - S	G	None		Pit toilets
WISCONSIN					
U.S. Army					
83. DePere Lock & Dam, DePere (Brown Co.)	0.4 S	G	ST, DF	A	500 gal. ST
84. Little Kaukauna Lock & Dam (Brown Co.)	0.2 S	G	ST, DF	A	500 gal. ST

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Installation (Name & Location)	Volume & type of wastes (1,000 GPD)	Receiving Waters	Treatment Provided	Rating	Remarks
WISCONSIN, Cont'd.					
U.S. Army					
85. Princeton Lock & Dam Princeton (Green Lake Co.)	0.4 S	G	ST, DF	A	
86. Kewaunee Engr. Depot, Kewaunee (Kewaunee Co.)	0.4 S	G	ST, DF	A	3 - 750 gal. ST & 2 Tile Fields (300 Total length)
87. Nike Milwaukee Site #54, Milwaukee (Milwaukee Co.)	-	G	ST, DF	A	Inactive; facilities used by local agency
88. Outgamie County (Fox River)					
Appleton Locks & Dams, Appleton					
89. No. 1	0.2 S	G	ST, DF	A	
90. No. 3	1 P - S	G	None	D	ST & DF proposed to replace privy
91. No. 4	1 P - S	G	None	D	" " " "
Kaukauna Locks & Dams, Kaukauna					
92. No. 1	0.3 S	G	ST, DF	A	
93. No. 2	0.5 S	G	ST, DF	A	
94. No. 3	1 P - S	G	None	D	Privy unsatisfactory
95. No. 4	1 P - S	G	None	D	Privy unsatisfactory

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Installation (Name & Location)	Volume & type of wastes (1,000 GPD)	Receiving Waters	Treatment Provided	Rat-ing	Remarks
WISCONSIN, Cont'd.					
U.S. Army, Cont'd.					
96. Rapid Groche Lock & Dam City of Kaukauna	0.2 S	G	ST, DF	A	
97. Cedars Lock & Dam City of Kimberly	0.2 S	G	ST, DF	A	
U.S. Coast Guard					
98. Green Bay Harbor Light Sta., Green Bay (Brown Co.)	0.4 S	Green Bay	None	B	Secondary package S.T.P. with Cl_2 is proposed. *
99. Sherwood Point Light Sta., Sturgeon Bay (Door Co.)	0.3 S	G	ST, DF	A	*
100. Sturgeon Bay Canal Station Sturgeon Bay (Door Co.)	3.00 S	G	ST, DF		Condition of drain fields unknown
101. Manitowoc Breakwater Lt.Sta., Manitowoc (Manitowoc Co.)	0.1 S 0.9 S	L.Mich. City Sewer	None	B	*
102. Plum Island C.G. Station (Door Co.)	1.2 S	G	ST, DF	A	Condition of system unknown
103. Green Bay Harbor Houseboat Light Sta., Green Bay (Brown Co.)	0.4 S	G	ST, DF		

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Installation (Name & Location)	Volume & type of wastes (1,000 GPD)	Receiving Waters	Treatment Provided	Rating	Remarks
WISCONSIN, Cont'd.					
U.S. Coast Guard, Cont'd.					
104. Kewaunee Pier Light Station Kewaunee (Kewaunee Co.)	0.4 S 0.7 S	L.Michigan City Sewer	None	B	Incinerator unit proposed. *
105. Rawley Point Light Station, Two Rivers (Manitowoc Co.)	0.9 S	G	ST, DF	A	*
106. Milwaukee Breakwater Light Station, Milwaukee (Milwaukee Co.)	(0.4 S)	(Lake Michigan)	(None)	A	Station unmanned on 8/1/66
	Previous discharge of raw wastes discontinued				
107 Racine Station, Racine (Racine Co.)	1.0 S 0.3 S	Root River Root River	ST None		Station is to be closed
108. Wind Point Light Station, Racine (Racine Co.)	(0.4 S)	(G)	(ST, DF)	A	This station has been unmanned and automated

* The Coast Guard has initiated a program to unman and automate all light stations in the Great Lakes as rapidly as funds are available.

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STATUS OF WASTE TREATMENT AT FEDERAL INSTALLATIONS LOCATED IN THE LAKE MICHIGAN DRAINAGE BASIN

Installation (Name & Location)	Volume & type of wastes (1,000 GPD)	Receiving Waters	Treatment Provided	Rating	Remarks
WISCONSIN, Cont'd.					
U.S. Forest Service					
Nicolet National Forest (C - camp sites; P - picnic sites)					
Oconto County					
109. Boot Lake Compound (42 C; 8 P)	225 P - S	G	8 pit toilets	B	Sec. Tr. plus Cl_2 proposed for FY 1969
110. Bass Lake Campsite	1 P - S	G	Pit toilet		
111. Boulder Lake Compound (54 C; 2 P)	95 P - S	G	10 pit toilets	B	Sec. Tr. plus Cl_2 proposed for FY 1969
112. Bagley Rapids Campground (16 C)	55 P - S	G	5 pit toilets	D	
113. Green Lake Picnic Ground (15 P)	75 P - S	G	4 pit toilets	D	
114. Wheeler Lake Picnic Gr. (6 P)		G	4 pit toilets	D	
115. Waupee Dam Picnic Gr. (1 P)		G	4 pit toilets	D	
116. Lakewood Ranger Hdqtrs.	1.5 S	G	ST, DF	A	

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Installation (Name & Location)	Volume & type of wastes (1,000 GPD)	Receiving Waters	Treatment Provided	Rating	Remarks
WISCONSIN, Cont'd.					
U.S. Forest Service, Cont'd.					
Forest Co.					
116. Laona Ranger Hdqtrs.	0.7 S	G	ST, DF	A	
117. 14 Campgrounds 130. (160 C, 40 P)	160 P - S	G	Pit privies	B	Sec. Tr. Facilities programed at unsatisfactory areas.
131. Franklin Lake Campground (87 C, 23 P)	3.5 S	G	ST, DF	A	
132. Florence Ranger Hdqtrs. Florence (Florence Co.)	1.0 S	G	ST, DF	A	
133. Long Lake Dwelling (Florence Co.)	0.3 S	G	ST, DF	A	
134.3 Campgrounds (13 C, 5 P) 136 (Florence Co.)	40 P - S	G	Pit toilets	D	
137. Eagle River Ranger Hdqtrs. Eagle River (Vilas Co.)	1.5 S	G	ST, DF	A	3 - 500 gal. ST & DF 1 - 900 gal. ST & dry well
138. Kentuck Lake Campground (Vilas Co.)	30 P - S	G	Pit toilets	D	

STATUS OF WASTE TREATMENT AT FEDERAL INSTALLATIONS LOCATED IN THE LAKE MICHIGAN DRAINAGE BASIN

Installation (Name & Location)	Volume & type of wastes (1,000 GPD)	Receiving Waters	Treatment Provided	Rat-ing	Remarks
WISCONSIN, Cont'd.					
U.S. Forest Service, Cont'd.					
139. Blackwell Job Corps (Forest County)	17.0 S	(Rat River) G	Sec., Cl_2, Polishing Pond	A	Polishing pond gives 30-day detention; effluent normally evaporates or transpires before reaching Rat River.

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STATUS OF WASTE TREATMENT AT
FEDERAL INSTALLATIONS LOCATED
IN THE
LAKE MICHIGAN DRAINAGE BASIN

Installation Name & Location (Berth)	Compliment	Area of Operation	Treatment Provided	Rating	Remarks
VESSELS					
U.S. Coast Guard					
USCGC Arundel (110' tug) (Chicago, Ill.)	20	Lake Michigan	Macerator-Chlorinator	D	Macerator-Chlorinator units do not provide adequate treatment.
USCGC Raritan (110' tug) (Milwaukee, Wis.)	20	"	"		"
USCGC Sundew (180' Bony Tender) (Charlevoix, Mich.)	47	"	None	B	Facilities to connect to city sewer system while in port scheduled for installation; holding tanks planned.
USCGC Mesquite (Sturgeon Bay, Wis.)	47	"	None	B	"
USCGC Woodbine (180' Buoy Tender) (Grand Haven, Mich.)	47	"	None	B	"

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LAKE MICHIGAN DRAINAGE BASIN

Installation Name & Location (Berth)	Complement	Area of Operation	Treatment Provided	Rating	Remarks
VESSELS					
U.S. Navy					
USS Parle (destroyer) (Chicago, Ill.)	185	Lake Michigan	None	**	Planning underway to connect to city of Chicago sewer system
USS Havre (destroyer escort) (Great Lakes Naval Training Ctr., Great Lakes, Ill.)	105	Lake Michigan	None	**	Wastes are discharged to a dockside connection at Great Lakes N.T.C. when in port.
USS Portage (destroyer escort) (Milwaukee, Wis.)	105	Lake Michigan	None	**	
USS Ely (destroyer escort) (Sheboygan, Wis.)	105	Lake Michigan	None	**	
USS Amherst (Detroit, Mich.)	120	Lakes Erie, Huron, Michigan & Superior	None	**	

** The Navy originally planned to install macerator/chlorinator units on these vessels. Available information indicates that these units have not been installed, but planning is underway to develop adequate treatment devices as soon as possible.

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Installation Name & Location (Berth)	Complement	Area of Operation	Treatment Provided	Rating	Remarks
VESSELS					
U.S. Army, Corps of Engineers					
LUDINGTON - Tug (Ludington, Mich.)	14	Lake Michigan	3 package maceration/ chlorination units		
KEWAUNEE - Dredge (Kewaunee, Wis.)	21	"	4 M/C units		
MILWAUKEE - Stone Barge (Milwaukee, Wis.)	7	"	2 M/C units		
SHEBOYGAN - Quarterboat (Sheboygan, Wis.)	18	"	5 M/C units		
TWO RIVERS - Tug (Two Rivers, Wis.)	8	"	1 M/C unit		
KENOSHA - Tug (Kenosha, Wis.)	3	"	1 M/C unit		
RACINE - Tug (Racine, Wis.)	2	"	1 M/C unit		

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FEDERAL INSTALLATIONS LOCATED
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LAKE MICHIGAN DRAINAGE BASIN

Installation Name & Location (Berth)	Complement	Area of Operation	Treatment Provided	Rating	Remarks
VESSELS					
U.S.Army, Corps of Engineers Cont'd.					
MANISTEE - Tender (Manistee, Mich.)	1	Lake Michigan	1 M/C unit		
OCONTO - Tender (Oconto, Wis.)	1	"	1 M/C unit		
Derrick boats: No. 7	2	"	1 M/C unit		
No.21	2	"	1 M/C unit		
MOORE - Tender (Indiana)	2	(Calumet Area)	1 M/C unit		
ESCANABA - Tender (Escanaba, Mich.)	1	"	1 M/C unit		
WINNECONNE - Crane Barge (Winneconne, Wis.)	5	Lake Winnebago-Fox River	1 M/C unit		