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CONFERENCE

Pollution of Lake Michigan and its tributary basin

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

U.S. Environmental Protection Agency

THURSDAY, FEBRUARY 1, 1968

MORNING SESSION

(9:30 a.m.)

MR. STEIN: May we reconvene?

While we get started, I think you will see that Assistant Secretary Max Edwards is at the table with us again today, and in addition we have a brand new Federal Water Pollution Control Administration Commissioner, Mr. Joe Moore, Jr., who was just sworn in this morning.

Please stand up, Mr. Moore, so they can see you.

(Applause.)

MR. STEIN: I think we also have an old friend from Illinois, Dr. C. S. Boruff, of Peoria.

And we have John Vogt, of Michigan, who is an old friend. Both of these people have worked in water pollution control for many years.

I have a tentative schedule now, so you people might be able to adjust your appointments.

We expect that the Federal presentation will take most of the day, if not the

MR. STEIN

complete day today.

Tomorrow we will have a presentation from Illinois.

We will recess as early as possible on Friday to enable those people who want to get back to their home base to make it before the weekend and have a recess Saturday and Sunday.

We will reconvene again on Monday morning. Monday morning Indiana will make its presentation. When Indiana has completed it, Michigan will make its presentation, which will possibly take the rest of the afternoon, possibly into Tuesday, and then Wisconsin will make its presentation.

We expect most of the presentations on the present schedule to be completed sometime on Tuesday, we hope fairly early. At that time we will have a discussion among the conferees and we should have this session of the conference, I hope, concluded by next Tuesday or Wednesday.

Before we begin, I believe Wisconsin has a procedural document it might want to insert in the record now.

MR. STEIN

Mr. Holmer.

MR. HOLMER: Mr. Chairman, first I would note at the table the presence of another old friend of yours, Ted Wisniewski, who is my assistant and an alternate today.

Next to him Tom Frangos, who is Director of our Water Resources Bureau and also an alternate today.

You indicate that next Tuesday we will be coming to the conclusion of this first section of the conference, and I have distributed to the members of this conference a document which suggests the form and some of the content that might be included in the summary and recommendations which come out of this conference. This document, which I intend should be entered in the record of this conference, is purely recommendatory and indicative. We think that the other members of the conference will find it a useful point of reference as they consider their participation in these proceedings.

MR. STEIN: Thank you, Mr. Holmer. Without objection, this document will be entered into the record as if read.

WISCONSIN PRESENTATION

OPENING STATEMENT

AT

LAKE MICHIGAN ENFORCEMENT CONFERENCE

"Wisconsin shares the widely-held hope that this conference will deal boldly and promptly with the issues before it. The quality of Lake Michigan is rightly our concern.

"We have considered, at length, the statutory purposes of the conference and how we might best contribute to the effectiveness of these deliberations. As our first contribution, I would offer the following suggestions with respect to the content and sequence of the discussions.

"The Federal Water Pollution Control Act does not define the agenda for this conference but it does declare that 'the Secretary shall prepare. . . .a summary of conference discussions including (A) occurrence of pollution. . . . subject to abatement under this Act; (B) adequacy of measures taken toward abatement of the pollution; and (C) nature of delays, if any, being

encountered in abating the pollution.' (Sec. 10 (d)(4))

"The Act further authorizes the Secretary, if he finds 'that effective progress toward abatement of pollution is not being made,' to 'recommend to the appropriate State water pollution control agency that it take necessary remedial action.'

"The summary and recommendations are the end product of this conference. They are, of course, the prerogative of the Secretary. However, Wisconsin recommends that the following data and conclusions be incorporated in the conference summary:

"A. Occurrence of pollution

"1. A listing of the municipal and industrial sources of waste discharge, with descriptions of each to include:

a. Minimum, maximum, and average daily volumes

b. Character of the discharge, showing at least

(1) Biochemical oxygen demand

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(2) Nutrients (if known)

(3) Toxic chemicals

(4) Temperature

c. Type of treatment

d. Nature of receiving water-course

"2. A summary narrative description of the pollution resulting from other manmade sources.

a. Dredging

b. Commercial and pleasure vessels

c. Urban and agricultural runoff (salt, fertilizers, pesticides)

d. Other hazards (e.g., oil, sedimentation, solid waste disposal)

"3. A description of other sources of pollution

a. Alewife

b. Rainfall

c. Natural runoff

"B. Adequacy of abatement measures

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"1. Acknowledgment that the quality of Lake Michigan shoreline waters has deteriorated and that corrective action has not been adequate.

"2. An affirmation that the water quality standards adopted by the States and approved by the Secretary are believed to be adequate to cope with the sources of pollution to which they apply.

"3. A finding that other sources of pollution may not be adequately controlled.

a. Dredging

b. Commercial and pleasure vessels

c. Urban and agricultural runoff

d. Alewife

e. Other hazards.

"4. Consideration of the necessity for zoning of the use of related land resources.

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"C. Nature of delays

"1. A general description of leadtimes required.

"2. Identification of research gaps and an estimate of the periods of time for filling them.

"3. Shortages of technical personnel.

"4. Organizational and legislative leadtime.

"5. Financial aspects

a. The role of Federal and State grants

b. The magnitude of the task

(1) Sewer separation

(2) Combined municipal-industrial and inter-municipal joint treatment

(3) Establishment of new districts

c. The need for a degree of certainty about future requirements.

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"The Secretary should, it seems to us, include with the conference summary specific recommendations to the States with respect to remedial action. Although final authority is his, it is hoped that each recommendation will be discussed at this conference. The following outline is intended to suggest an appropriate sequence for such a discussion. It is recognized that many elements are interdependent but some clearly precede others.

"1. Recommendations relating to research and investigation

"a. Present research programs

"b. Proposed investigations, indicating

(1) Priorities

(2) Timetable

(3) Assigning specific responsibilities

"2. Data needs

"a. Water monitoring

"b. Related shoreland uses

"3. Treatment standards and methods

"4. Collection standards

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"5. Organizational recommendations

"6. Legislative recommendations

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MR. STEIN: Now I would like to call on Assistant Secretary Edwards for a short statement.

Mr. Edwards.

ASSISTANT SECRETARY EDWARDS

STATEMENT BY THE HONORABLE
MAX N. EDWARDS, ASSISTANT SECRETARY
UNITED STATES DEPARTMENT OF THE INTERIOR

ASSISTANT SECRETARY EDWARDS: Conferees, ladies and gentlemen.

Earlier yesterday while I was rummaging through Secretary Udall's file to find some material to fulfill his commitments, I came across a letter which I think pointedly describes the problem, although it may describe it simply. The letter is as follows:

"My Dear Mr. Secretary:

"Last evening my fourth grade son asked if he could describe to me his homework project, a drawing of the city. He proceeded to point out the John Hancock Center, the Eisenhower Expressway, an apartment complex, office buildings, an airplane in an approach to O'Hare Field, and in the center of the picture, 'A polluted river.' Nothing ever said to me by one of my six children has made such an impact as that 'polluted river.' That a child his age

ASSISTANT SECRETARY EDWARDS

must include in his knowledge of the world about him in such matter-of-fact terms 'a polluted river' is the shame of our generation. How I wish he could have said 'A wild river.' For Tommy's sake, let's get going."

I think that that sets the theme for this conference. From my own personal view, it sets the theme for recommendations after we have found the sources of pollution to Lake Michigan. It sets the theme for the recommendations that we will make to the Secretary to abate these sources of pollution. If they are not abated we will have to take the proper action to do so.

Thank you.

MR. STEIN: Thank you, Mr. Edwards.

Mr. Poston, would you go on with the Federal presentation, please.

FEDERAL PRESENTATION (CONTINUED)

STATEMENT BY H. W. POSTON
DIRECTOR, GREAT LAKES REGION
FWPCA, DEPARTMENT OF THE INTERIOR

MR. POSTON: I am H. W. Poston, Regional Director of the Federal Water Pollution Control Administration (FWPCA) of the Department of the Interior. I am responsible for the administration of the Federal Water Pollution Control Program in this area, which includes Lake Michigan.

In the century and a half that people have lived along the shores of Lake Michigan, this body of water has been used and abused, to such an extent that today we are at a critical time in its history. In a number of local areas, a crisis condition exists. The nature of this crisis is illustrated by the fact that not too many years ago the City of Chicago was still drawing drinking water from the lake and treating it only with chlorine. Today this water must go through an extensive and sophisticated treatment process. Pollution has been increasing at such an accelerating pace in the past few years that the most

modern methods of water treatment used by Chicago have been taxed on occasion to produce a drinking water of satisfactory quality. Many other instances of impairment of water quality around the shores of the lake could be cited. Scientific evidence of this will be presented later in reports by other Federal representatives.

Our senses of sight and smell also tell us that we are faced with a polluted resource, where oil spills discolor the water, where algae pile up in windrows on the beaches, and where wastes of every variety are seen floating by. The visibility of pollution has aroused the people of this area; they are demanding a cleanup.

The management of Lake Michigan must be a combined Federal, State and local effort. The lake is an interstate and national asset even though pollution is created at the local level. Federal financial and technical assistance is available; but where it cannot be provided, local government and local industry must assume responsibility for controlling their pollution. In fact, local leadership is imperative to the success of this program. If nothing else is

accomplished at this conference but to create this sense of responsibility and urgency at the local level, then this meeting will have gone far in accomplishing its goals.

The Federal water pollution control program was launched just over a decade ago when the Federal Water Pollution Control Act of 1956 was signed into law. This Act and its subsequent amendments recognize the primary right and responsibility of the States to prevent and control water pollution. The Federal program provides for a cooperative attack upon water pollution through numerous approaches, such as:

grants to municipalities for construction of treatment works;

program grants to State water pollution control agencies;

training grants to educational institutions and to individuals;

grants for research and development and planning;

establishment of water quality standards, and

enforcement actions such as this.

Assistance is also provided to industries through investment tax credit, through the indirect benefits of Federal assistance to municipalities, and through grants for industrial research. All phases of this program have been brought to bear at the Federal, State and local levels in the Lake Michigan area, but a greater effort is obviously needed.

Today we have an unparalleled opportunity, not only to improve this water resource for future generations but, more importantly, we have the opportunity to move now to clean up the lake for our own use. The question has been asked, "Can the lake be saved?" This is not the issue here today. The lake must be saved. The issue as I see it is: Do we have the will to save it?

Later on we will submit recommendations which will provide a program for saving the lake. We have the resources, we have the technology, we have the legal and administrative authority, and most importantly we have an aroused press and public, all of which now makes possible a meaningful effort to preserve Lake Michigan.

While we must recognize all legitimate

uses of our water resources, we must at the same time change our concept of using our lakes and streams as natural dumping grounds for wastes. We must recognize that Lake Michigan and its tributaries are a limited resource that requires the wisest management to meet the constantly increasing needs of our growing population and industry. Let us recognize that although an effective water pollution control effort will be expensive, it will be much less costly than the incalculable damage this water resource will suffer if we do not act now.

Little more than a century ago the Lake Michigan area was a frontier, its waters pure and undefiled. Today the frontiers have gone. We have no choice but to preserve and enhance our heritage of clean water in Lake Michigan. I believe this conference will begin that action.

I would now like to proceed with presentation of reports which will provide the basis for recommendations for pollution control. First a report will be presented on the general pollution problems of Lake Michigan and its tributaries by

Mr. R. J. Schneider, Deputy Regional Director of the Federal Water Pollution Control Administration's Great Lakes Region. This will be followed by a report on eutrophication by Dr. A. F. Bartsch, Eutrophication Research, Pacific Northwest Water Laboratory. Dr. D. J. Baumgartner, Coastal Pollution Research, also of the Pacific Northwest Laboratory, will present a report on the results of a study of lake currents and, finally, Dr. Leon W. Weinberger, Assistant Commissioner for Research and Development, will report on new developments in advanced waste treatment. This will be followed again by Mr. Schneider, who will summarize our recommendations.

I ask that any questions be held until all presentations have been made.

I would like to start off at this time, then, with Mr. Schneider.

This afternoon I hope to start off with General Tarbox, Division Engineer of the Corps of Engineers, to be followed by Mr. Bathurst, Department of Agriculture, then with Mr. Carbine, Bureau of Commercial Fisheries, Mr. LaPointe, the Bureau of Sport Fisheries, Mr. Koenings, of

the Bureau of Outdoor Recreation, Mr. Bishop, the Mineral Resource Office of the Bureau of Mines, and Mr. Marshall of the Department of Health, Education, and Welfare, followed by Captain Anderson of the Navy, Captain Shepard of the Naval Facilities Engineering Command, and Mr. James, Regional Forester, U. S. Department of Agriculture.

Mr. Schneider.

R. J. SCHNEIDER

STATEMENT BY R. J. SCHNEIDER
DEPUTY REGIONAL DIRECTOR, GREAT LAKES REGION
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION

MR. SCHNEIDER: Thank you very much, Mr. Poston.

Commissioner Moore, Chairman Stein, distinguished conferees, ladies and gentlemen.

It is a privilege to present to this conference the report prepared by the Federal Water Pollution Control Administration for use by the conferees in their consideration of actions needed to improve and preserve the quality of waters in the Lake Michigan Basin. This report with its supporting documents, is based on studies and investigations by FWPCA, on reports by other Bureaus of the Department of the Interior, on information obtained from other Federal agencies, from the States, and from other available sources. Most of the supporting documents are referenced in the report. This report, entitled "Water Pollution Problems of Lake Michigan and Tributaries,"

has been made available for general distribution and can be obtained in the lobby at the entrance to this conference room.

Mr. Chairman, at this time I would like to have this report in its entirety introduced into the record.

MR. STEIN: Without objection, it will be done, it will be entered into the record as if read.

(Which said report, entitled "Water Pollution Problems of Lake Michigan and Tributaries," follows this statement, commencing on page 523.)

MR. SCHNEIDER: In my presentation I will follow the general outline of the report, which contains background information and a description of the basin; a description of the major water uses and water pollution problems; and then before presenting the conclusions and recommendations, there will be the separate presentations by experts from our Department on eutrophication, lake currents and advanced

waste treatment.

I would first like to invite your attention to the map on the wall. The area covered by this conference, as defined in the Secretary's letter calling the conference, is outlined by the dotted line on the map which is the boundary of the Lake Michigan drainage basin. This area is also shown in Figure 1 of the Report. The total drainage area of this basin is 67,900 square miles, of which, 22,400 square miles are occupied by the lake proper, and an additional 1,000 square miles of the watershed area is occupied by some 8,100 smaller lakes. As you can see from the map, nearly two-thirds of the land area is within the State of Michigan, less than a third is in Wisconsin; five percent is in Indiana; and only a fraction of one percent is in the State of Illinois. The Illinois portion does not include the area which was once a part of the Lake Michigan watershed, but whose drainage has been diverted to the Illinois River watershed for pollution control purposes.

The Lake Michigan watershed is

characterized by large concentrations of people and industry, as well as agricultural activity. In 1960, 5.5 million people lived within its boundaries, 2.2 million each in Michigan and Wisconsin, slightly less than 1 million in Indiana and about 140,000 in Illinois. Millions live in nearby areas, including nearly 7 million people in the Chicago Metropolitan Area who are directly concerned with this water resource. The population of the watershed has nearly doubled in the last 50 years and predictions are that it will probably double again during the next 50 years.

The first slide, which is Figure 2 in the Report, shows the distribution of the major population centers in the basin. The largest of these areas are: the Milwaukee area; the Gary-Hammond-East Chicago area and the Grand Rapids-Lansing, Michigan area. You will note that the Chicago Metropolitan Area is not shown on this map as part of the basin, but the people in this area are more dependent on Lake Michigan than many others who live within the watershed.

R. J. SCHNEIDER

The next slide, which is Figure 3 in the Report, shows the distribution of industrial activity in the basin. As would be expected, the distribution of industry closely coincides with the population pattern. The principal industries, as indicated on the map, are: Food and Kindred Products; Paper and Allied Products; Chemicals and Allied Products; Petroleum and Coal Products; and the Primary Metal Industries. The primary metal industries are concentrated in the Milwaukee area and in the Gary-Hammond-East Chicago area. The other industries are generally distributed throughout the other industrial centers.

In 1963 the value added by manufacturing activity in the Lake Michigan Basin totaled almost $10 billion; and manufacturing employed 834,000 people. Most of these industries are those requiring large quantities of water and discharging substantial quantities of wastes. Growth of these industries is expected to be substantial and to approximate the national industrial growth rate, which is expected to increase sixfold in the next 50 years.

Agricultural activity is extensive in the basin. The value of farm products accounted for by counties of the watershed amounted to $900 million in 1964. In that year, there were approximately 2.4 million cattle on watershed farms. Production of crops, including fruits, is also substantial.

Commercial shipping is an important activity in the Lake Michigan Basin. During the 10-year period between 1955-1964, annual commerce on the Great Lakes averaged 190 million tons. Eighty-five percent of this traffic was comprised of four major commodities, iron ore, coal, stone and grain. This commerce was processed at 27 Federal harbors and 15 private harbors. Commerce on the Great Lakes can be expected to increase in the years to come roughly in proportion to the expected growth in industrial activity.

Lake Michigan itself comprises one of the greatest fresh water reservoirs in the world. In addition to its vast surface area, a better appreciation of the magnitude of this resource can be gained from a realization that

in some places the depth of this lake reaches over 900 feet, with an average depth of 276 feet. The volume of this water is 1,170 cubic miles. The outflow of the lake through the Straits of Mackinac is 48,000 cubic feet per second, with an additional outflow of 3,200 cubic feet per second by diversion at Chicago. Despite the large volume of this outflow it represents only one percent of the volume of water in the lake.

Some idea of the relationship of the tributary streams to the lake itself can be had from the next slide, identified as Table 1 in the Report. This Table shows 20 major streams in the basin. These streams, draining 80 percent of the watershed area, vary in mean discharge from 130 cfs in Burns Ditch to over 4,000 cfs in the Fox River in Wisconsin. These figures are presented here to show the magnitude of the tributaries' flow compared to the size of the lake and its total outflow.

Although this conference is primarily concerned with the surface waters of the basin, there is considerable utilization of groundwater

for municipal and industrial water use. While most of the larger municipalities which lie on or near the lake shore use Lake Michigan for municipal water supply, the majority of the smaller communities further from the lake use groundwater as a source of supply. In the future, however, it is anticipated that greater reliance will be placed upon surface water sources.

One of the most important characteristics of Lake Michigan from the standpoint of pollution, is the movement of water within the lake due to currents generated by external and internal influences. The importance of a knowledge of currents in Lake Michigan has long been recognized and a detailed investigation was conducted by the Great Lakes Region several years ago. It revealed that there is a general mixing of the waters throughout the lake. A report of the findings of the study has been published recently, and because of the importance of this work, Dr. D. J. Baumgartner, in charge of coastal pollution research at our Pacific Northwest Water Laboratory, will present later

in this conference a review of the lake currents information.

The foregoing has been a brief description of the salient characteristics of the Lake Michigan Basin. I will now describe some of the more important water uses in the Basin.

Lake Michigan is an important source for municipal water supply. Fifty municipalities treat an average of 1.47 billion gallons of Lake Michigan water daily; of this, over 1 billion gallons per day are utilized by the City of Chicago and its suburbs.

The demand for municipal water supply from Lake Michigan is anticipated to increase threefold in the next 50 years. The value of Lake Michigan waters for municipal water supply is one of the principal reasons why the quality of this lake must be preserved. The next slide shows one of the major water treatment plants on Lake Michigan. This is a view of the central district filtration plant of the City of Chicago, which processes a major portion of the 1 billion gallons per day mentioned previously.

Industries are major users of water

from Lake Michigan. Present usage is estimated at 4.25 billion gallons per day. Nearly 80 percent of this usage is by Indiana industries. It is anticipated that the demand for industrial water will increase about threefold by the year 2020, although the gross industrial output will increase much more. This lower proportionate usage of water will result from increased efficiency and reuse in manufacturing processes.

This next slide is a view of construction at Bethlehem Steel Company's new plant at Burns Ditch, Indiana. This slide, from page 12 of the Report, is an example of an additional water use from Lake Michigan, and is indicative of the trend toward drawing an increasing amount of water from the lake rather than the tributary streams. The use of water by industry on the tributaries even now is small when compared to what is drawn from the lake. On the tributaries the largest industrial use is from the Fox River and Lake Winnebago, by the pulp and paper industries.

Another major use of water in this basin is for electric power generation, in

hydroelectric and thermal plants. The use of water for cooling is on a once-through basis in both the fossil-fuel and nucleartype thermal electric plants. There are 110 hydroelectric generating plants in the basin with an installed capacity of 318,000 kilowatts. Virtually all of the economically practicable hydroelectric sites have already been utilized. Hydroelectric power generation is minor when compared to the total of 8,500,000 kilowatts of installed thermal electric generation capacity in the basin. Fossil-fuels, principally coal and gas, provide the energy for all of this electric power capacity except for 50,000 kilowatts provided by the Big Rock nuclear power station at Charlevoix, Michigan.

Lake Michigan has been an attractive location for large power plants. Two reasons are the ready availability of a large quantity of cooling water, and the proximity to a large market of cities and industries.

The next slide, which is Figure 6 of the Report, shows the location of the existing and planned thermal electric generating plants.

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 of 4.5 million kilowatts. In addition there are 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, burning either coal or gas.

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 the lake. Five additional nuclear plants are proposed or under construction, three 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 five million kilowatts. Thus, by 1973 the southern basin of

the lake will be ringed with power plants having an electric output of 11 million kilowatts. Six of the plants will be fossil-fueled and three nuclear-fueled. Two of the latter will be dual unit plants. Power plants will become one of the major users of Lake Michigan water in the future, and I will discuss this more fully later under the subject of waste heat.

Commercial fishing has always been a significant part of the economy of the Great Lakes. The U. S. Fish and Wildlife Service in a report entitled, "Fish and Wildlife Resources of Lake Michigan," has indicated a steady decline in both quantity and quality of this fishery. This decline has been related more closely to biological and economic factors than to water quality. Pollution, however, does have an effect on the fishery of the lake. Many of the species rely on tributary streams and shore areas for spawning grounds.

Water oriented recreation is a major water use in the Lake Michigan Basin. This Basin is one of the most abundantly endowed areas of any in the country for this use. The

preservation and improvement of the water quality within the Basin is imperative to maintain this status. The U. S. Bureau of Outdoor Recreation in this report, entitled "Water Oriented Outdoor Recreation in the Lake Michigan Basin", identifies most of the facilities that are available, the problems that are developing and the actions that must be taken to preserve this natural heritage. Copies of this report are available upon request to our office. This recreation report lists 625 recreational areas scattered throughout the Basin of which 536 are water oriented, and these include 74 recreational harbors on Lake Michigan itself.

The next slide, Figure 5 of the Report, shows the distribution of the 74 recreation harbors about the lake. These are shown by the black circles around the shores.

Closing of some of the water-oriented recreational facilities in the southern portion of the Basin because of pollution has resulted in crowding of other facilities in the area.

This slide, Figure 4 of the Report, shows the location of some of the Lake Michigan

beaches that have been closed. And these are indicated by the black and partially black circles. Swimming is the largest form of water-oriented recreation. The total length of the Lake Michigan shoreline as indicated on the slide is over 1,600 miles. Seventy-five percent of this length is suitable for general recreation, although only ten percent is classified as beaches by the Bureau of Outdoor Recreation. Only 80 miles of this shoreline are public recreation areas.

In 1960 there was a total of 176 million activity days of water related or water oriented recreation activities. The demand for these activities will increase both in proportion to the increase in population and to the attractiveness of the water environment that we are able to maintain in this Basin.

Sports fishing is the second largest form of water oriented recreation. The Fish and Wildlife Service estimates 19 million angler days per year are spent in the Lake Michigan Basin, and this is expected to triple

by the year 2010. To satisfy this demand, particularly in the localities of dense population, much greater pollution control efforts will be required to maintain and restore water quality, both in Lake Michigan and its tributaries which are the major spawning grounds of sport fish.

The value of the Lake Michigan Basin for recreation and esthetic enjoyment, which is part of most recreational uses, is difficult to measure; just how difficult is illustrated by the next two slides.

How can a monetary value be attached to the enjoyment of these young fishermen or, on the next slide, to such bathing scenes? Surely activities such as these must continue to be a part of our way of life in this area.

I would now like to discuss some of the general water pollution problems of Lake Michigan and its tributaries. Since Lake Michigan and the thousands of smaller lakes within the basin were formed, the quality of their waters has undergone continuous and progressive change as a result of fertilizing

effects of waste inputs from both natural phenomena and the activities of man. Nutrient materials in municipal and industrial wastes, and in rural runoff are the principal causes of the fertilizing effect. Some of the effects of the deterioration in water quality caused by these waste inputs are readily apparent, while others are revealed only in subtle warning signs of trouble to come unless action is taken now.

Overproduction of algae is occurring in many parts of the lake, which indicates an acceleration of the natural aging or eutrophication process. This overproduction of algae is occurring both in the microscopic floating types and the attached filamentous types. As in the case of lake currents, eutrophication is considered one of the most crucial issues of this conference, and because of this, Dr. A. F. Bartsch, Chief of Eutrophication Research, of this Department will present a report of his studies of this phenomena in Lake Michigan. The present rate of eutrophication is a threat now to the usefulness of Lake Michigan and to other

lakes within the Basin.

The next slides from pages 21 and 23 of the Report are illustrations of some of the signs of the threat that overfertilization is causing. This is not a monster from the deep but Cladophora algae clinging to a rock in the water near Saugatuck, Michigan, a southern Michigan resort area. The second shows algae growing in the water of a harbor area on the Wisconsin shores. Scenes such as this are becoming increasingly common around the lake. The third slide shows windrows of algae typical of what washed up on many Lake Michigan beaches last summer (1967). The scene is Calumet Park beach in Chicago. Other water uses such as for municipal supply are also adversely affected by algae. These conditions are sure to worsen and spread throughout the lake, unless measures are taken now to stem the input of fertilizing materials.

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 nutrient or fertilizing material from wastewaters. There is a 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 will probably be some form of three-stage treatment: physical, biological, and chemical. It is important to note that this will not render obsolete the two-stage, 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.

The next slide, from page 29 of the Report, shows the discharge from the Jackson, Michigan, sewage plant, a well operated secondary plant that is an example of the need for advanced waste treatment. This necessary step in the improvement of municipal and industrial waste treatment practices must be accompanied by a similar improvement in agricultural practices, to reduce inputs from such sources as feedlots,

dairying operations and application of fertilizers.

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. In this connection, Dr. Leon Weinberger, Assistant Commissioner of the Federal Water Pollution Control Administration for Research and Development, will present a special discussion of the feasibility of advanced waste treatment.

Another problem is bacterial pollution. The presence of coliform bacteria is an indication of deteriorated water quality. 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 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 open water but is degraded along the shoreline and in harbor areas. Referring to the wall map, evidence of severe bacterial pollution of tributaries has been found: in the Fox River between Lake Winnebago and Green Bay; in the Milwaukee River within Milwaukee County; and in and downstream from the cities along the Grand River in Michigan in the St. Joseph River of Indiana and Michigan; and in the streams of the Calumet Area in Illinois and Indiana.

This next slide, which is shown on page 25 of the Report, illustrates the effect of this problem where bacterial contamination has forced the closing of beaches, such as the one shown here at Hammond, Indiana.

A number of other Lake Michigan beaches are closed, either intermittently or

permanently, because of health hazard. Also permanently closed is the Bay View Beach at the southern end of Green Bay. This beach was closed many years ago because of bacterial pollution. The Bay View Beach is also an example of the effects of accelerated eutrophication. The beach is now clogged with aquatic weeds and its once sandy bottom is covered with the dead and decaying remains of weed crops of previous years. The next slide, by courtesy of the Chicago Tribune, is a recent view of the former beach area.

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 stormwater and raw sewage are discharged without treatment during and after every heavy rain. This pollutional overflow is the principle reason that Milwaukee beaches on Lake Michigan have to be closed part of the time. Elimination of combined sewer overflows is one of the most essential and yet most vexing

problems faced in the abatement, not only of bacterial pollution, but of all of the other pollution contained in this raw waste discharge.

Chemical pollution of Lake Michigan and its tributaries is also a problem. This pollution by dissolved chemicals covers a broad range of substances, sources, and effects. The principal source of this pollution is 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.

Areas of local chemical pollution exist around centers of industrial activity and commercial shipping. The Calumet Area, Milwaukee harbor and its tributary streams, and the southern end of Green Bay are examples of such areas. 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. Details concerning the Milwaukee area and the Green Bay area are given in reports published by FWPCA last year.

The next slides show examples of chemical pollution. The first is the discharge from a glue factory near Milwaukee; the second shows a plume of pollution in the Fox River from pulp and paper industries; and the third slide shows the discharge from a steel manufacturing plant in the Calumet Area.

Oxygen depletion also constitutes a pollution problem in many areas of the basin. The small quantity of oxygen normally dissolved in water, approximately 1/1,000 of one percent by weight, 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. Generally, when these conditions prevail the esthetic value of the water resource will be impaired or maybe completely destroyed.

Thermal pollution from the waste heat contained in the cooling water from industrial plants is becoming a matter of increasing concern in the Lake Michigan Basin, particularly in reference to the discharges from thermal electric power plants which I have described previously. Of particular concern is the trend toward larger plants which will result in the

concentrated discharge of cooling water in volumes generally much greater than have been used in the past. Some realization of the voracious demand for cooling water that these larger nuclear installations will have can be had in comparison with the flows of the Lake Michigan tributaries which were shown on the previous table. The volume of cooling water needed for a single of the larger plants is in the same order of magnitude as the mean discharge from the largest of the tributary streams to Lake Michigan.

Because of the large volume of water in the lake there does not appear to be any danger of an overall warming of the lake itself, but the addition of such large volumes of heated water could promote growth of algae and cause changes in the aquatic environment in the general vicinity of these plants. There is a general lack of information in regard to these effects, and additional research and investigation is necessary to more fully understand them in order to make judgments concerning the design and location of these large power

plants.

The next slide, from page 30 of the Report, shows the largest existing thermo-electric generating plant in the basin, the Oak Creek plant at Milwaukee, which will soon be exceeded in capacity by several of the proposed nuclear plants.

The pollutional effects of hydro-electric generation are minimal. However, in streams that have become highly nutrified, the reservoirs behind the power dams may have algal problems and the water released from the power plants may be low in dissolved oxygen. Also, the operation of the hydroelectric plants 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.

Another pollution problem upon which attention has been focused because of the proposed nuclear power plants in this area is the potential for buildup of radioactive contamination in the lake. Although what are termed high level wastes are usually adequately controlled, there are many

operations in a nuclear power plant which produce contaminated liquids having a low level of radioactivity. These are usually discharged to the immediate environment in dilute form. The AEC Regulations and State Regulations governing radioactive discharges have generally been established on the basis of discharge to a moving stream. The particular concern for Lake Michigan arises from the fact that it has a very small discharge rate, and any radioactive material entering into the lake 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, on October 12, 1966, indicated the desirability of a special evaluation of the impact on 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. Such an evaluation is considered imperative before final commitments are made for locating reactors on the lake.

Wastes from 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 tend to intensify local problems of bacterial pollution.

A report entitled, "Pollution of Navigable Waters of the United States by Wastes from Watercraft," was submitted to the Congress on June 30, 1967 by Secretary Udall. This report has been published as Senate Document No. 82 of the 90th Congress. The report recognizes and analyzes the serious pollution problems that are caused by all types of watercraft, including pollution from sewage, garbage, and oil wastes. Implementation by Congress of the recommendations made in this report can provide an effective means for combating the vessel waste problem on Lake Michigan. The Department has also proposed legislation to Congress based on this report.

Some significant progress has been made in the vessel pollution 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 harbors of the lake within the City's jurisdiction. Where vessels are equipped with treatment facilities, discharge is prohibited unless the effluent will not degrade the waters below the established water quality standards.

There is a need for uniform regulations throughout this lake for controlling the discharge of wastes from watercraft, and the actions taken by the City of Chicago could well serve as a basis for such uniform lakewide controls.

Oil pollution has become a major water pollution problem in the Lake Michigan Basin. 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 cause treatment problems at water treatment plants. In some cases these discharges are toxic to desirable fish and aquatic

life.

Oil contamination has been observed in many areas of the basin. The next slide, from page 35 of the Report, shows the principal location in which it occurs. This is a view of Indiana Harbor. Of the number of oil discharges and spills reported by the Coast Guard in 1967, 20 occurred in the Calumet Area. However, as the next slide shows, Figure 7 of the Report, no area of the lake has been immune from spills. Spills were reported even in the northern portion of the lake.

One of the major needs discussed in a study of oil spills by a Presidentially appointed task group was the development of a contingency plan to deal with the emergencies created by spilling of oil and other hazardous substances. Such a plan would involve the Federal, State and local agencies with due regard to each agency's statutory responsibilities and capabilities. The development of such a plan throughout the Great Lakes Region is already in the preliminary stages.

The disposal of dredged material has become of increasing concern on Lake Michigan

because of the long-term cumulative effect of incremental additions of pollutants to the lake. This is particularly important in Lake Michigan because of the minimal flushing action obtained in this cul-de-sac lake. Among the visible results of open water disposal of polluted dredged materials, which can be seen on the next slide, are the discoloration, increased turbidity, and oil slicks. This 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 lake fill areas.

This photograph also appears on page 41 of the Report. The pollutants contained in the dredged material may also contribute to increased concentrations of dissolved solids and chemicals which contribute to deterioration of water quality.

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. In fiscal year 1966, 1-1/2 million cubic yards were dredged from harbors on Lake Michigan.

The next slide, Figure 8 of the Report, shows the location of the harbors where dredging takes place. They are identified by the black circles on the shores of the lake.

The Corps of Engineers has followed the practice of disposing of this material in authorized dumping grounds in the open waters of the lake. However, during the past season alternate disposal sites were obtained for disposition of materials from three of the most polluted Lake Michigan harbors, that is, Indiana Harbor, the Calumet Harbor and Green Bay. It is expected that alternate disposal will be provided for additional Lake Michigan harbors during the 1968 dredging season. In this connection, the Corps and the Federal Water Pollution Control Administration are cooperating in a study which has the objective of finding alternate means of

disposal of this polluted material.

A dramatic example of an upset in the balance of nature is the invasion of the Great Lakes by the alewife. These fish are descendants of a species which has migrated into the lakes from the ocean and not fully adapted itself to the fresh water environment. They 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, 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. The next slide, from page 43 of the Report, shows an affected area. Here 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. It reached record proportions during last spring and early summer, when deaths estimated in the billions occurred.

As a result of a recommendation by a special task force appointed by Secretary Udall, the Department 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 aquatic life. Although there has been no evidence that pollution was a direct cause of the deaths, the possibility cannot be ruled out of an indirect influence through pollution-caused changes in the ecological balance of the lake.

Pollution of Lake Michigan from pesticides is evident from water quality studies and biological investigations.

The use of pesticides in the United States has expanded rapidly in recent years. The total market value was over $1 billion 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.

The places in the Lake Michigan drainage basin where pesticides are used most heavily are the areas of extensive fruit growing. Referring to the wall map, 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.

A study by the FWPCA 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 concentrations as high as 7,800

micrograms per kilogram. Maximum concentration found in bottom sediments was close to 3,000 micrograms per kilogram, which was many times that of the overlying water at the time of the study. The algae contained still greater amounts than did the bottom sediments. Our 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.

The significance of the synthetic organic pesticides is 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.

Because of the limited information available on pesticide application, use and effects, a much more intensified effort needs to be made at all levels of government in terms of regulation, control, and research to eliminate pesticides from the waters.

Altnough perhaps overshadowed in recent years by water pollution problems caused by municipalities and industries, one of the oldest

known problems of water pollution is that resulting from siltation. Sediment suspended in water impairs it for nearly all legitimate uses. Deposition of the material in streams, reservoirs and lakes affects fish spawning beds, decreases reservoir capacity and obstructs navigation. The major source of sedimentation is from poor agricultural practices, although construction activities and urban runoff are also contributors. Much has been done by agricultural agencies to improve soil conservation practices, but a much more intensified effort is indicated to be compatible with the higher degree of treatment that is indicated for municipalities and industries. Studies on a number of selected watersheds in Wisconsin indicate that the suspended sediment yield per square mile is of such magnitude that if the same rate is incident over the entire watershed, over 3 million tons of sediment are contributed to the waters of the basin annually. Vivid visual evidence of this suspended sediment can be seen during periods of high runoff and especially from aerial observation at the mouths of the tributary streams. Agricultural

agencies, Federal, State and local, need to take renewed action to reduce siltation to the maximum practical extent.

Because this is a report by a Federal agency, pollution problems from Federal installations merit specific attention. Federal installations in the Lake Michigan Basin are also sources of wastes. These installations are listed in the Appendix to this report and vary in size from those using pit-type toilets in recreational areas of the national forests to the large treatment facilities at the Navy Great Lakes Training Center and the Army Fort Sheridan. These latter two installations account for three-fourths of all wastes generated by independently discharging Federal sources in this basin. A coordinated effort to get the Federal house in order is being made under the impetus of Presidential Executive Order 11288, which directed heads of Federal activities to provide leadership in the nationwide water pollution control program. This Executive Order also applies to Federal watercraft, to Federal water resource projects and to facilities

supported by Federal loans, grants or contracts.

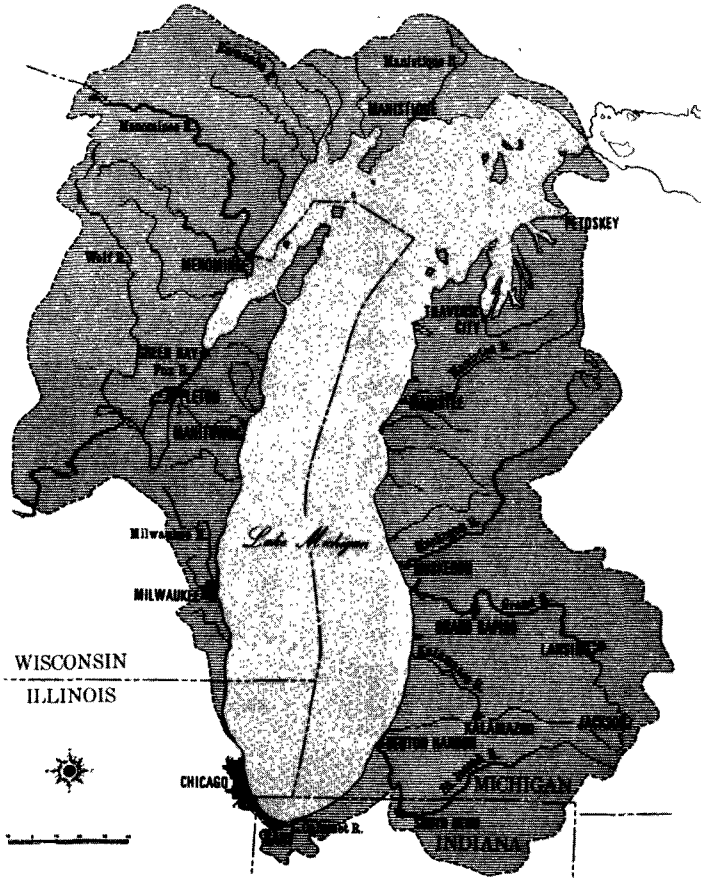
The water pollution problems just enumerated are being dealt with through the on-going cooperative pollution control programs at the Federal, State and local levels of government. This enforcement action is one part of this cooperative effort.

These on-going pollution control programs also include provisions for financial assistance, for research, for establishment of water quality standards, for planning and for other related activities. While these efforts have been significant, a greatly expanded effort is considered necessary in order to preserve the quality of the waters of the Lake Michigan Basin.

Before presenting the conclusions and recommendations for the preservation of these waters, it would be appropriate to hear the presentations on eutrophication, lake currents and advanced waste treatment. So at this time, Mr. Chairman, I would like to postpone the conclusions and recommendations until after these three presentations have been made.

(The report referred to is as follows:)

WATER POLLUTION PROBLEMS OF LAKE MICHIGAN AND TRIBUTARIES



ACTION FOR CLEAN WATER
P.L. 84-660

JANUARY 1968

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

WATER POLLUTION PROBLEMS

of

LAKE MICHIGAN AND TRIBUTARIES

ACTIONS FOR CLEAN WATER

JANUARY 1968

UNITED STATES DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
Great Lakes Region Chicago, Illinois

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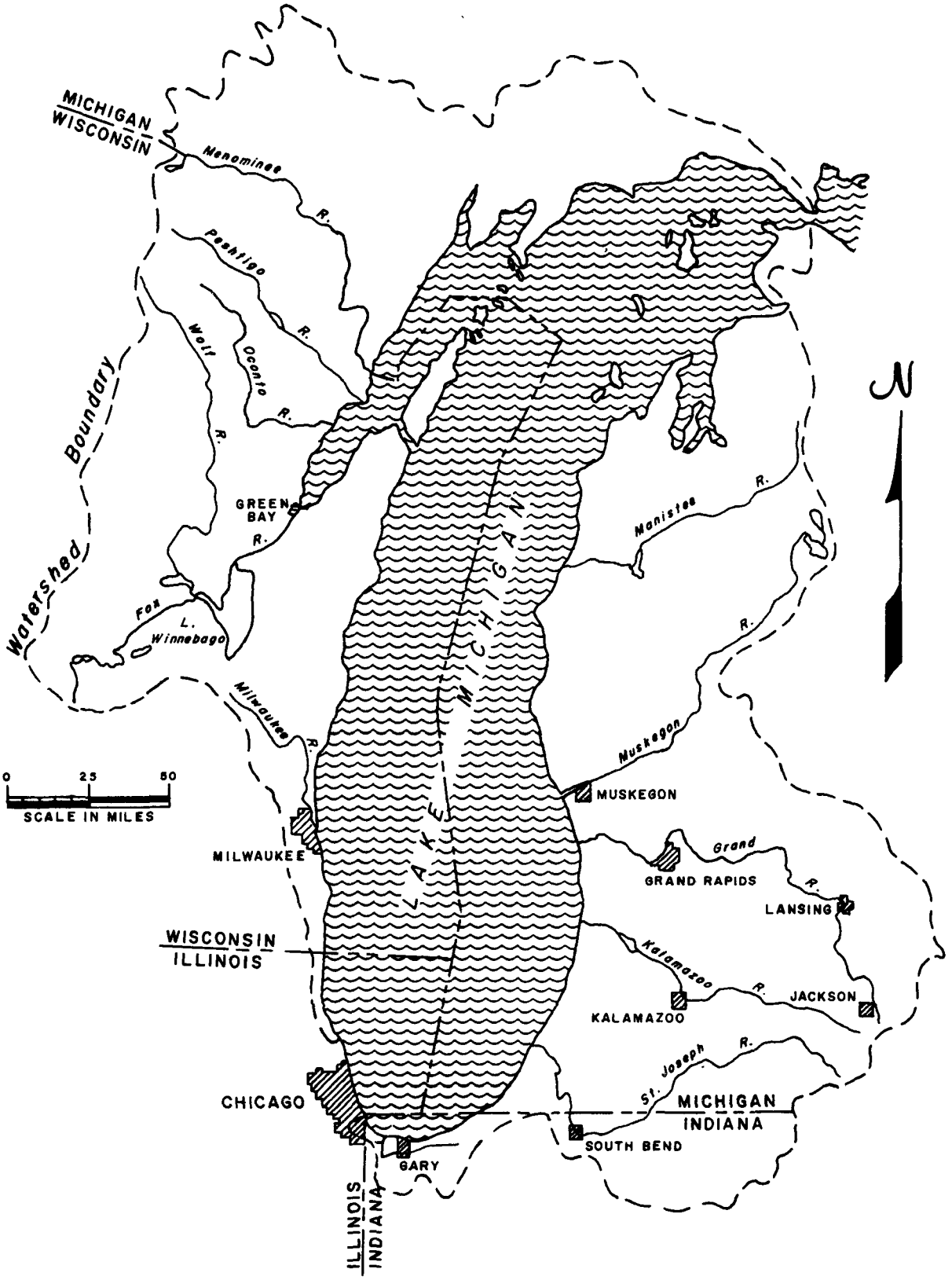
I - INTRODUCTION

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.

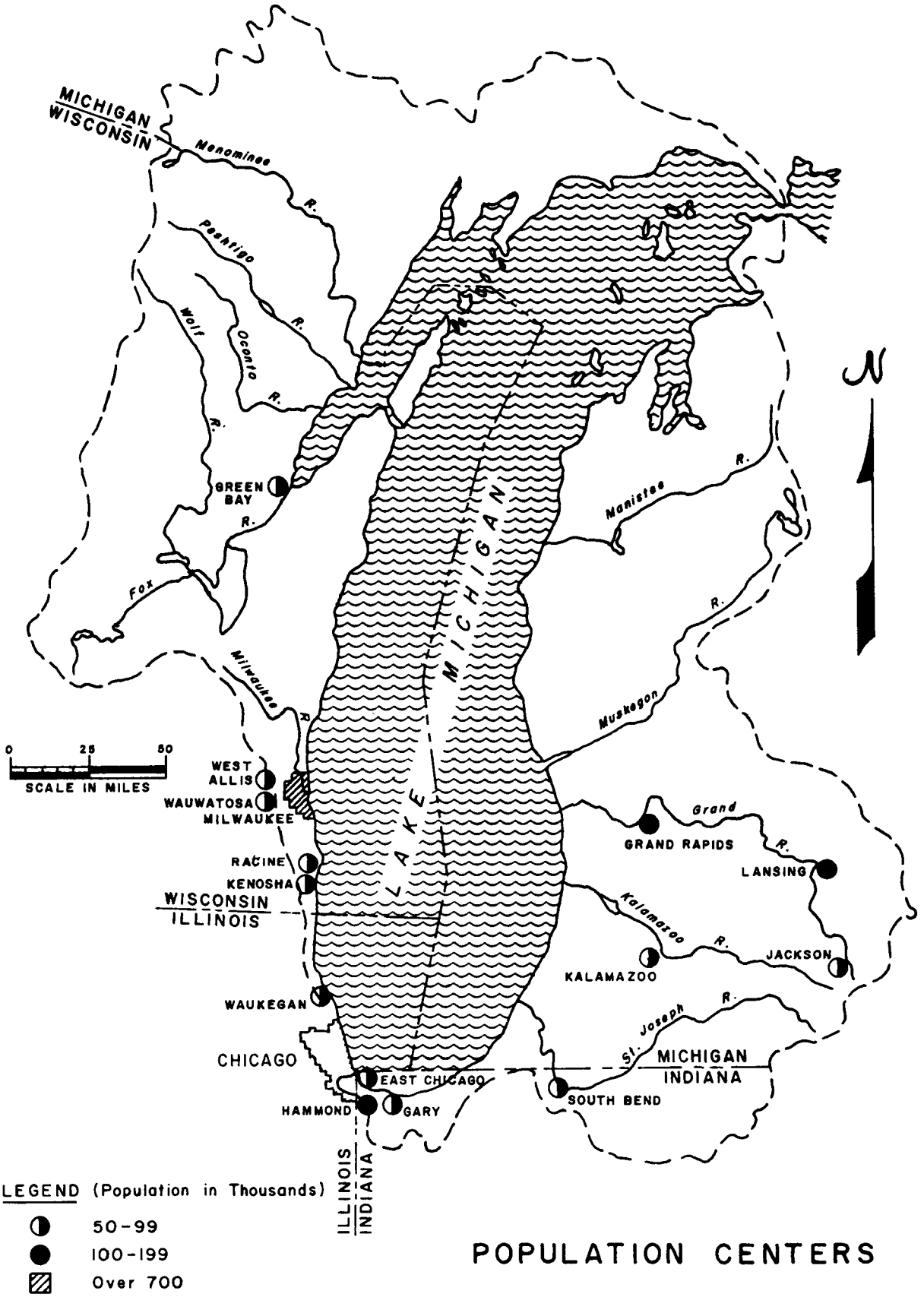
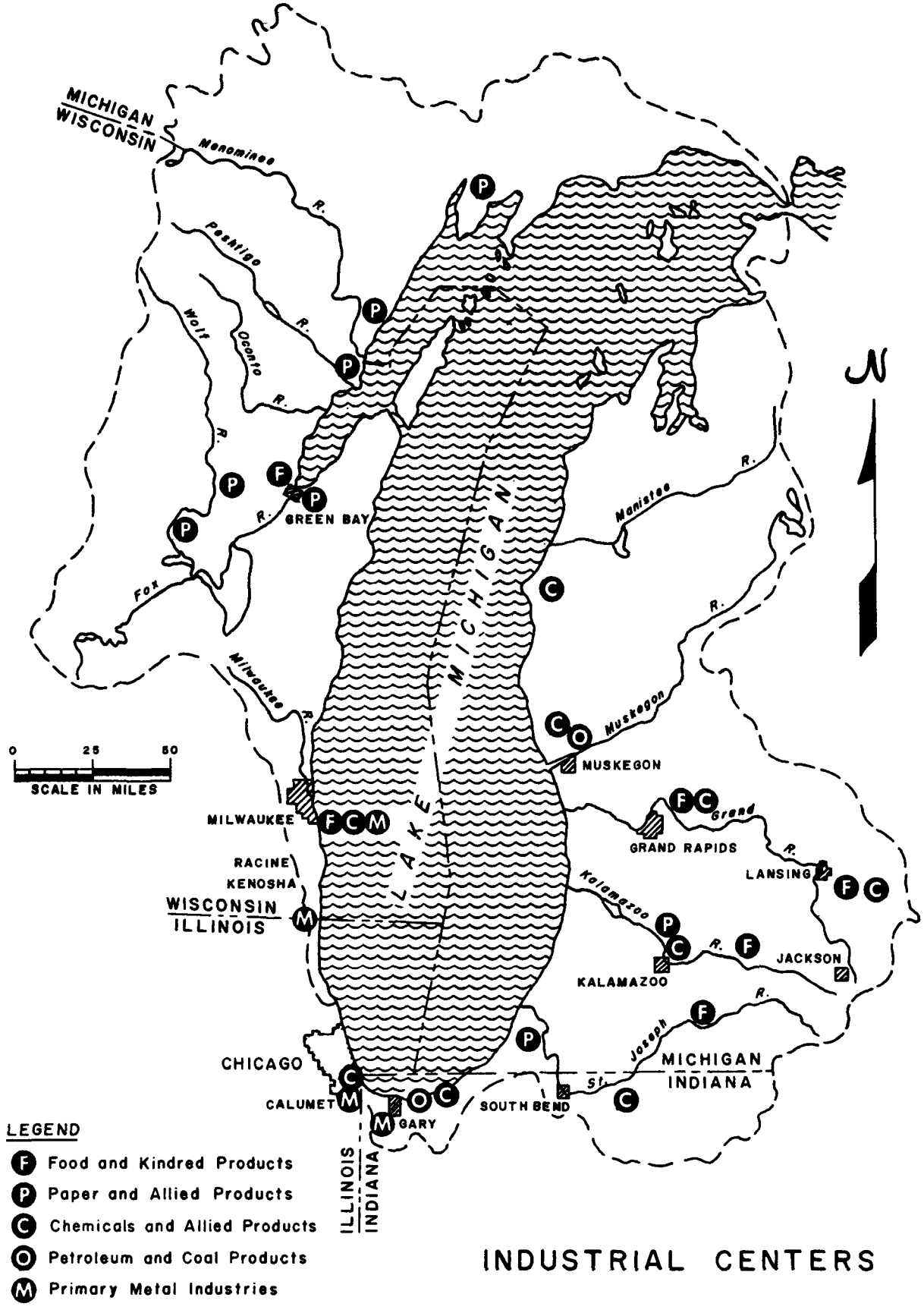

MICHIGAN
WISCONSIN
Menominee R.
Peshtigo R.
Wolf R.
Oconto R.
Fox R.
Milwaukee R.
GREEN BAY
MANISTEE R.
Manistee R.
Muskegon R.
Grand R.
Kalamazoo R.
St. Joseph R.
LAKE MICHIGAN
N
0 25 50
SCALE IN MILES
WEST ALLIS
WAUWATOSA
MILWAUKEE
RACINE
KENOSHA
WISCONSIN
ILLINOIS
WAUKEGAN
CHICAGO
EAST CHICAGO
HAMMOND
GARY
ILLINOIS
INDIANA
GRAND RAPIDS
LANSING
KALAMAZOO
JACKSON
SOUTH BEND
MICHIGAN
INDIANA
LEGEND (Population in Thousands)
50-99
100-199
Over 700
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.

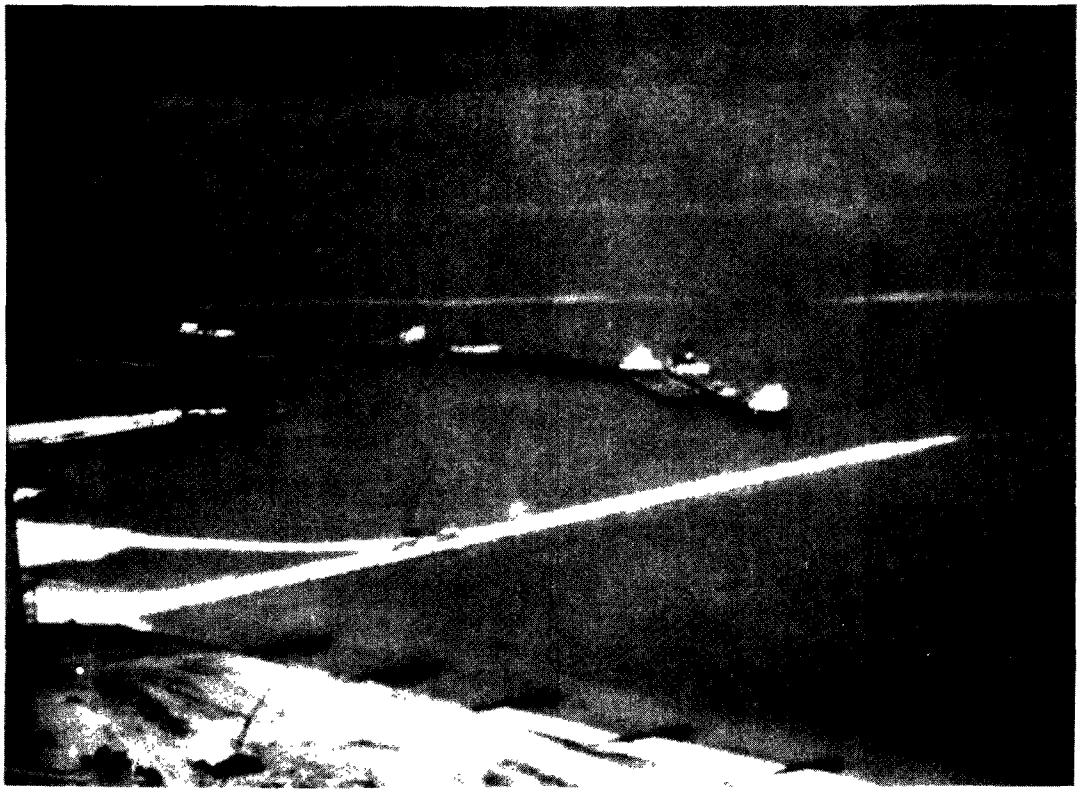
Because currents in the lake are motivated principally by the wind, and winds are variable, horizontal movement of the lake water exhibits an infinite variety and frequent changes in both direction and speed. Nevertheless, certain recurring patterns have been identified, resulting from the fact that 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.

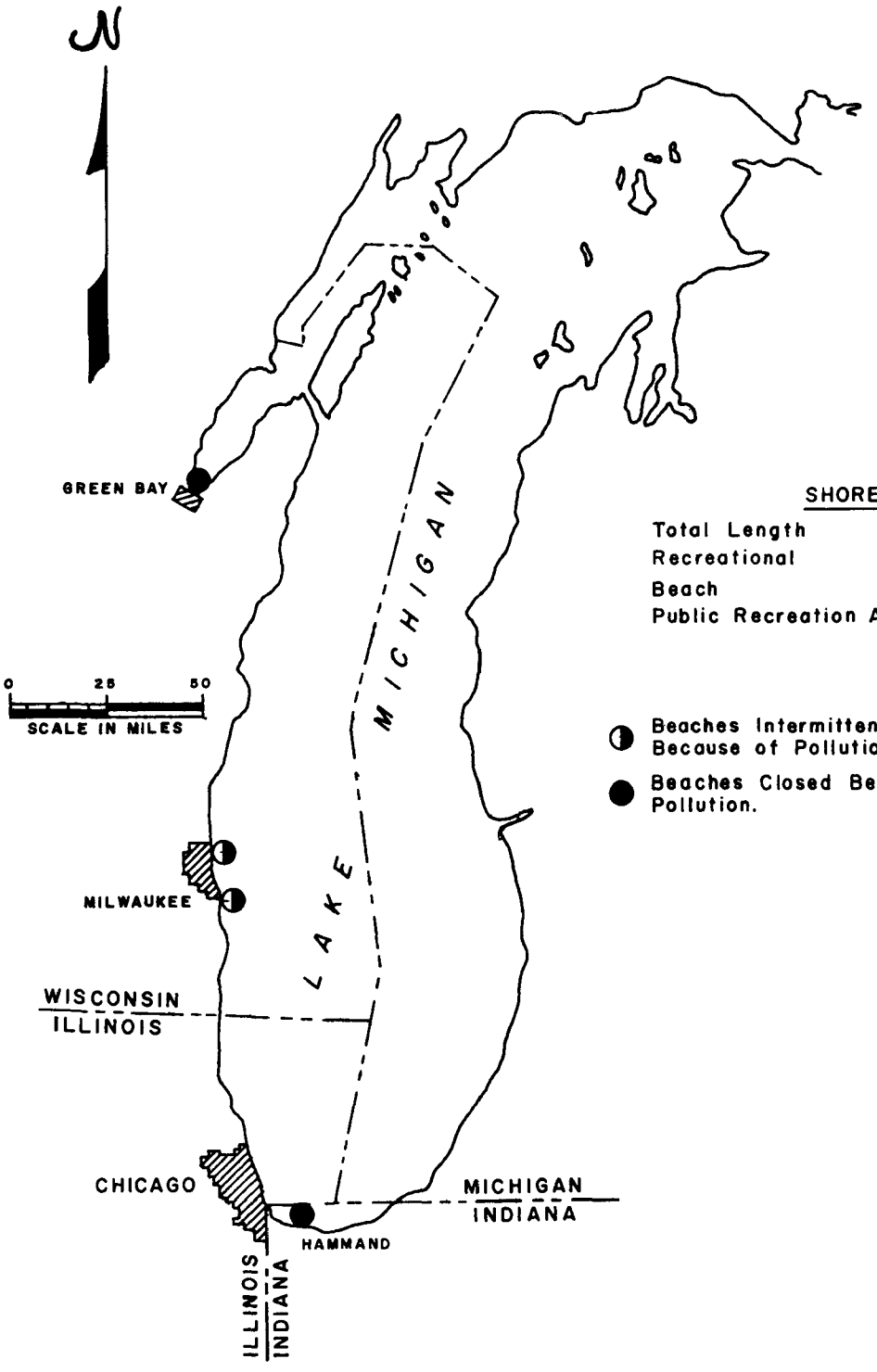
The United States Fish and Wildlife Service has prepared a report on the Fish and Wildlife resources of Lake Michigan. (16) The commercial fishing industry has always been a significant part of the economy of the Lake Michigan Basin. Since 1879, the total annual commercial catch has averaged 26.5 million 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.

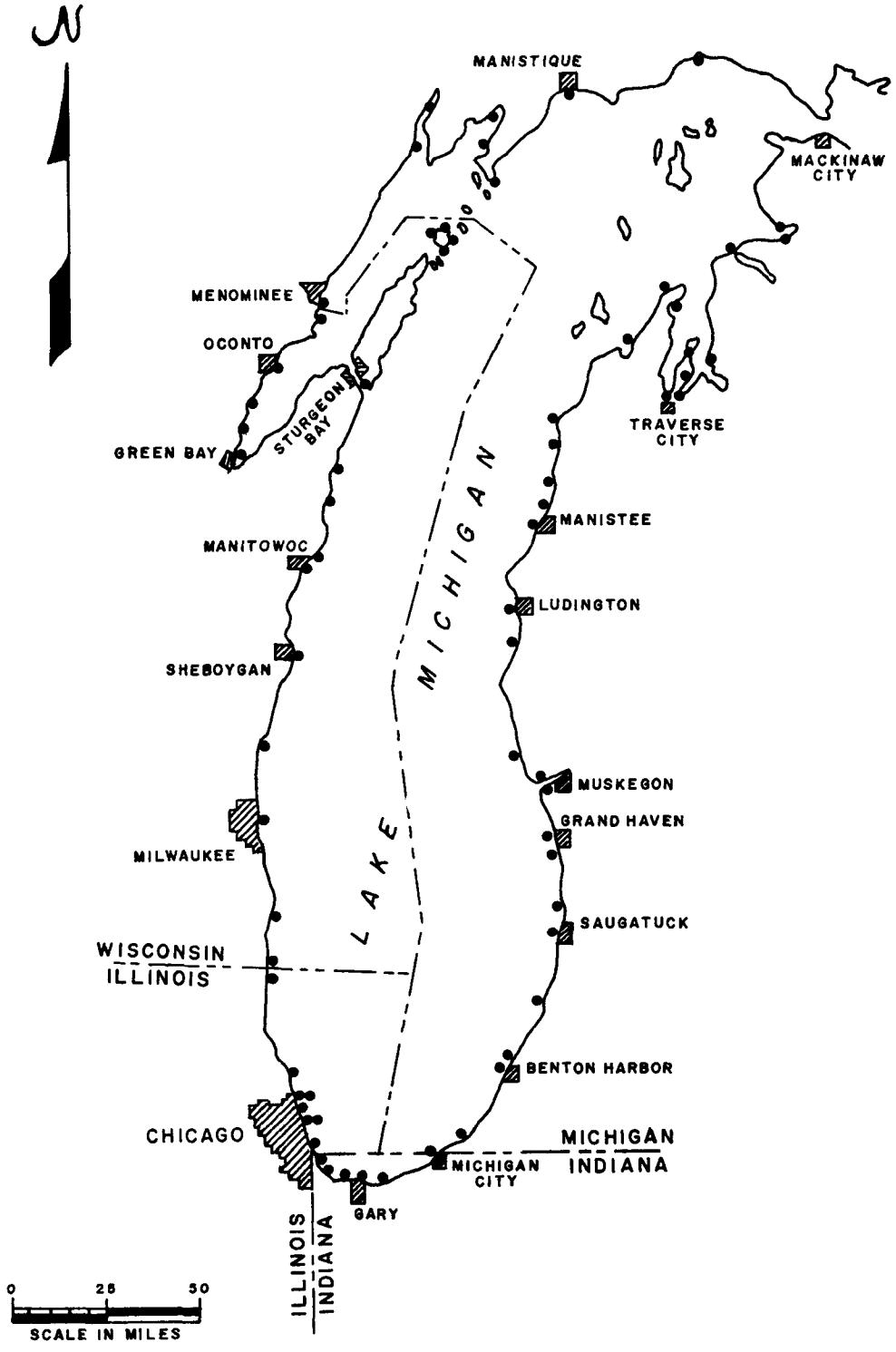
Ice fishing is a popular winter sport in the Lake Michigan Basin.

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

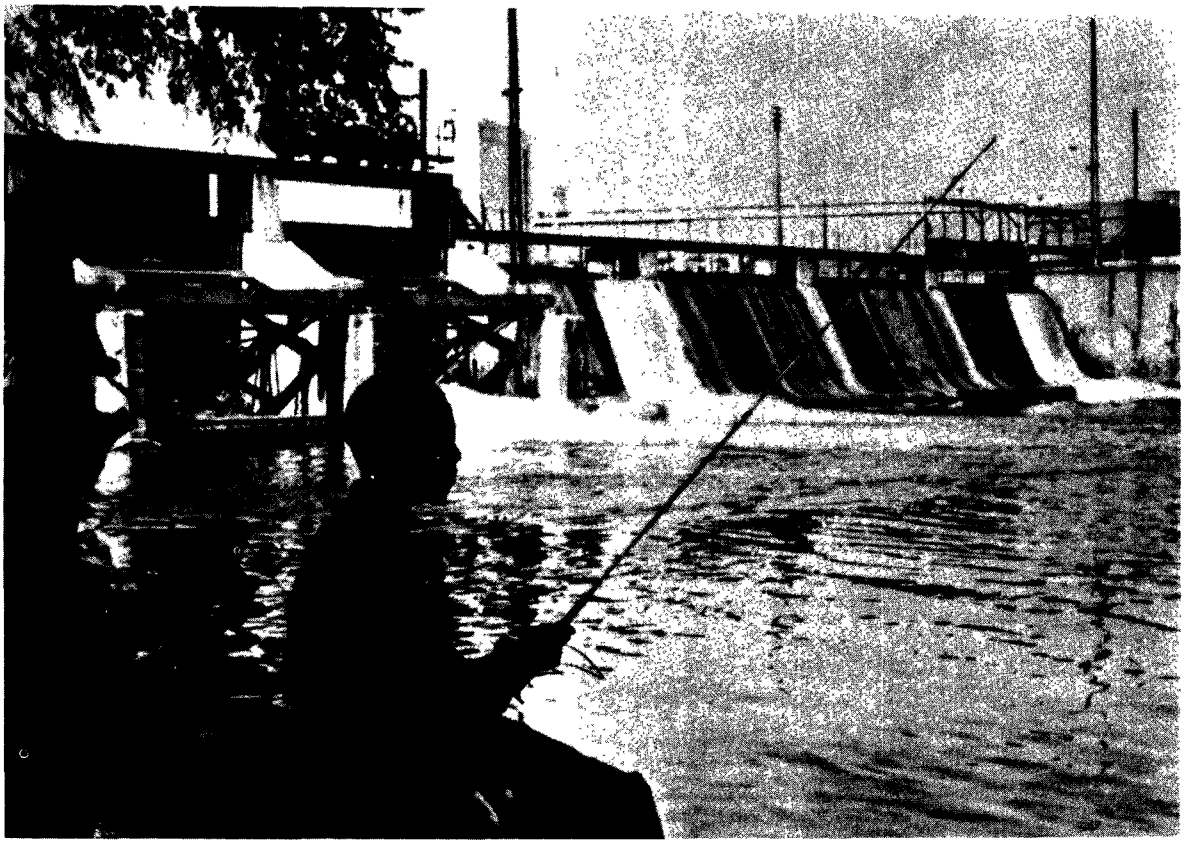
A pleasure boat heads toward the harbor mouth and the open waters of Lake Michigan. There are 74 recreational harbors on the Lake.

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.

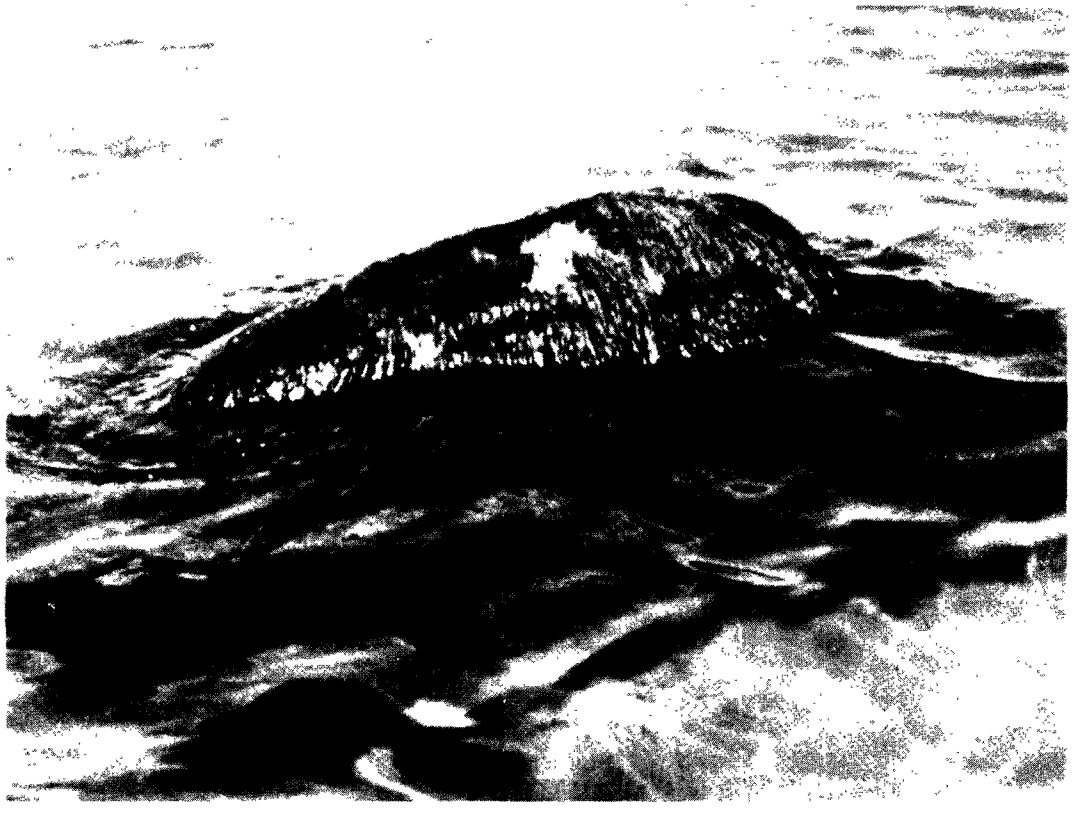


Fishing in Lake Michigan and its tributaries is the second largest form of water recreation around the lake, topped only by swimming.

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.

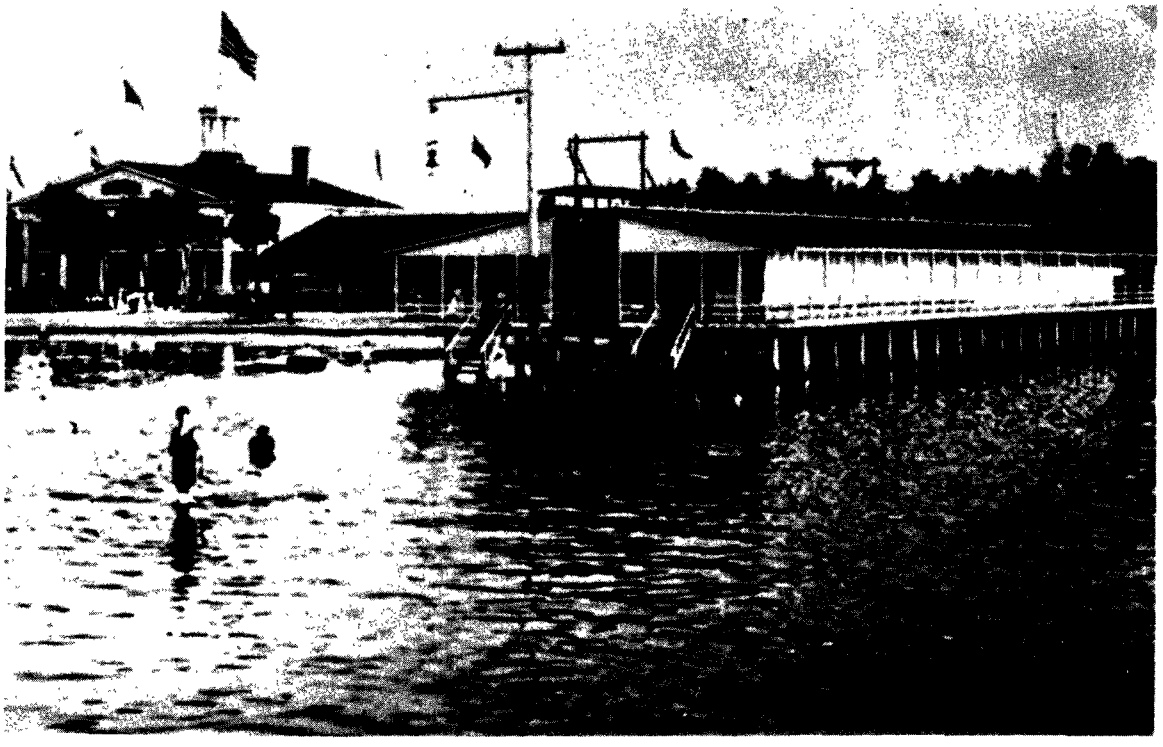
Summing up what has just been said: eutrophication is a threat now, to the usefulness of Lake Michigan and other lakes within the Basin; feasible methods exist for bringing this problem under control. They need to be applied.

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.)

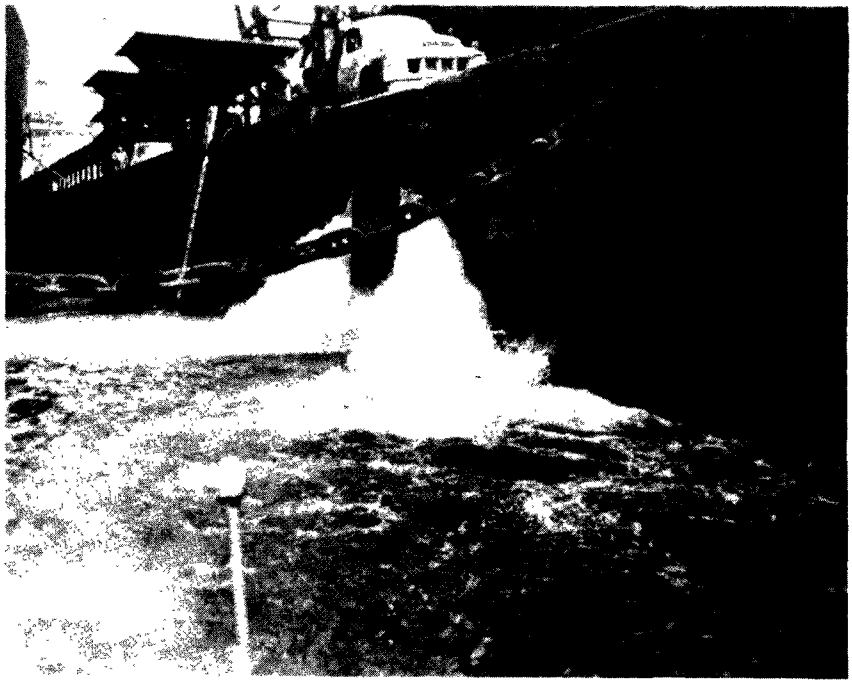
A number of Lake Michigan beaches are closed, either intermittently or permanently, because of health hazard. Permanently closed are some beaches in the Calumet Area and a beach at the southern end of Green Bay. The latter area exhibits also an example of the eutrophication discussed earlier. The Bay 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.

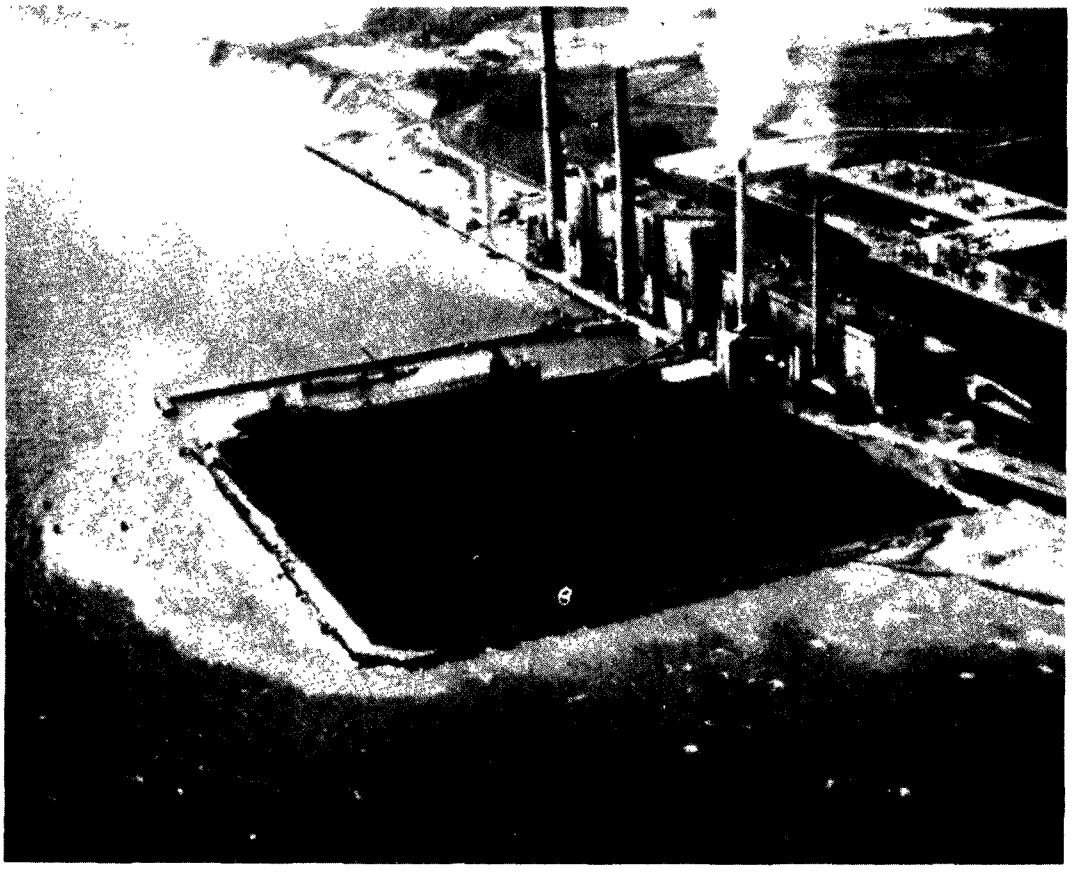
This load of detergents has been discharged by the Jackson, Michigan, sewage treatment plant into the Grand River, a Lake Michigan tributary.

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).

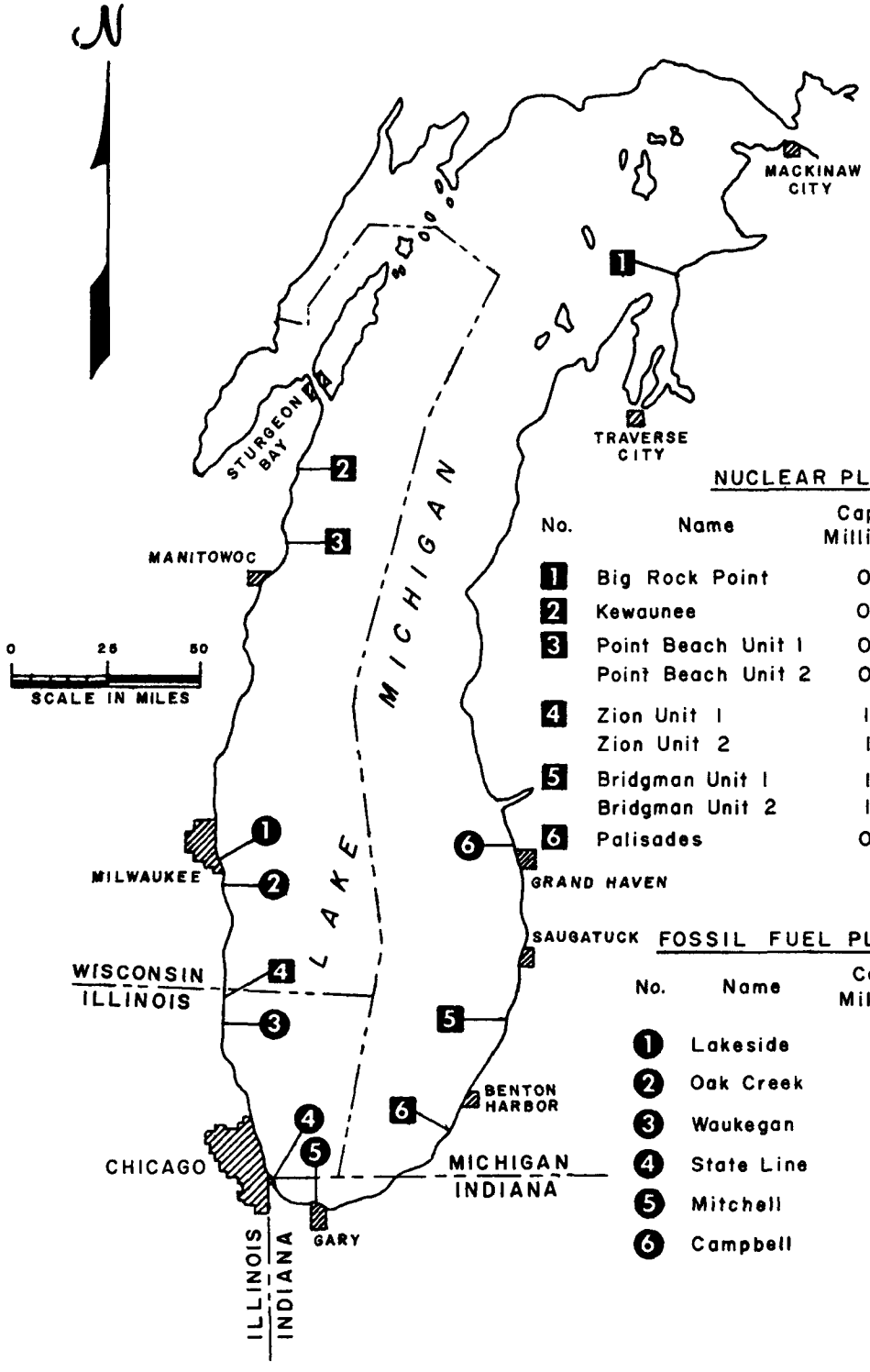


Wisconsin Electric Power Company at Oak Creek, Wisconsin, south of Milwaukee, is one of the many power plants located in the southern basin of Lake Michigan.

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 base-line 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.

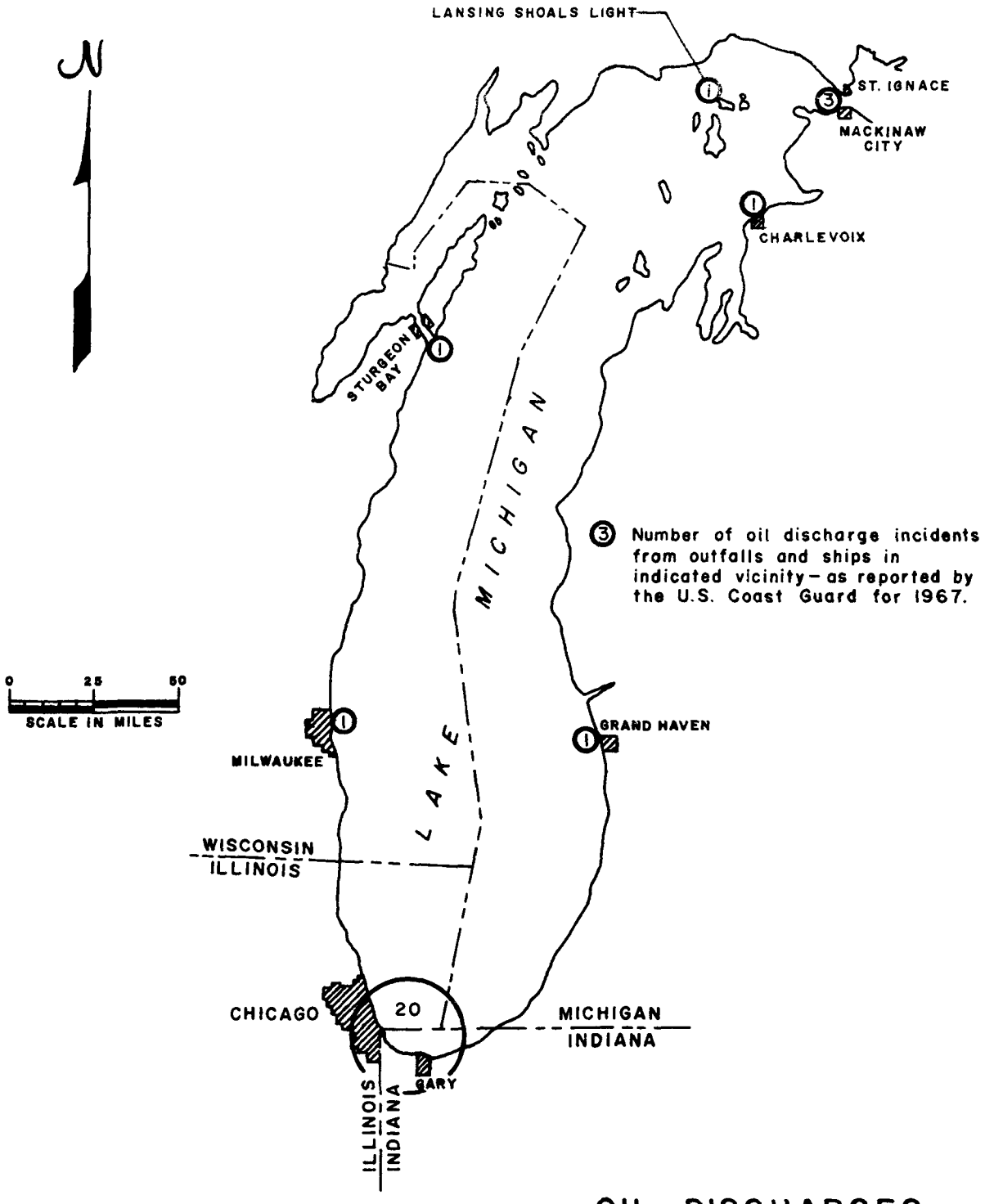
The Torrey Canyon ship disaster, which involved a major spill of oil off the coast of England in 1966, focused attention on the detrimental effects of oil contamination on recreational facilities and on fish and aquatic life. It also pointed up the need for additional study of existing resources and 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

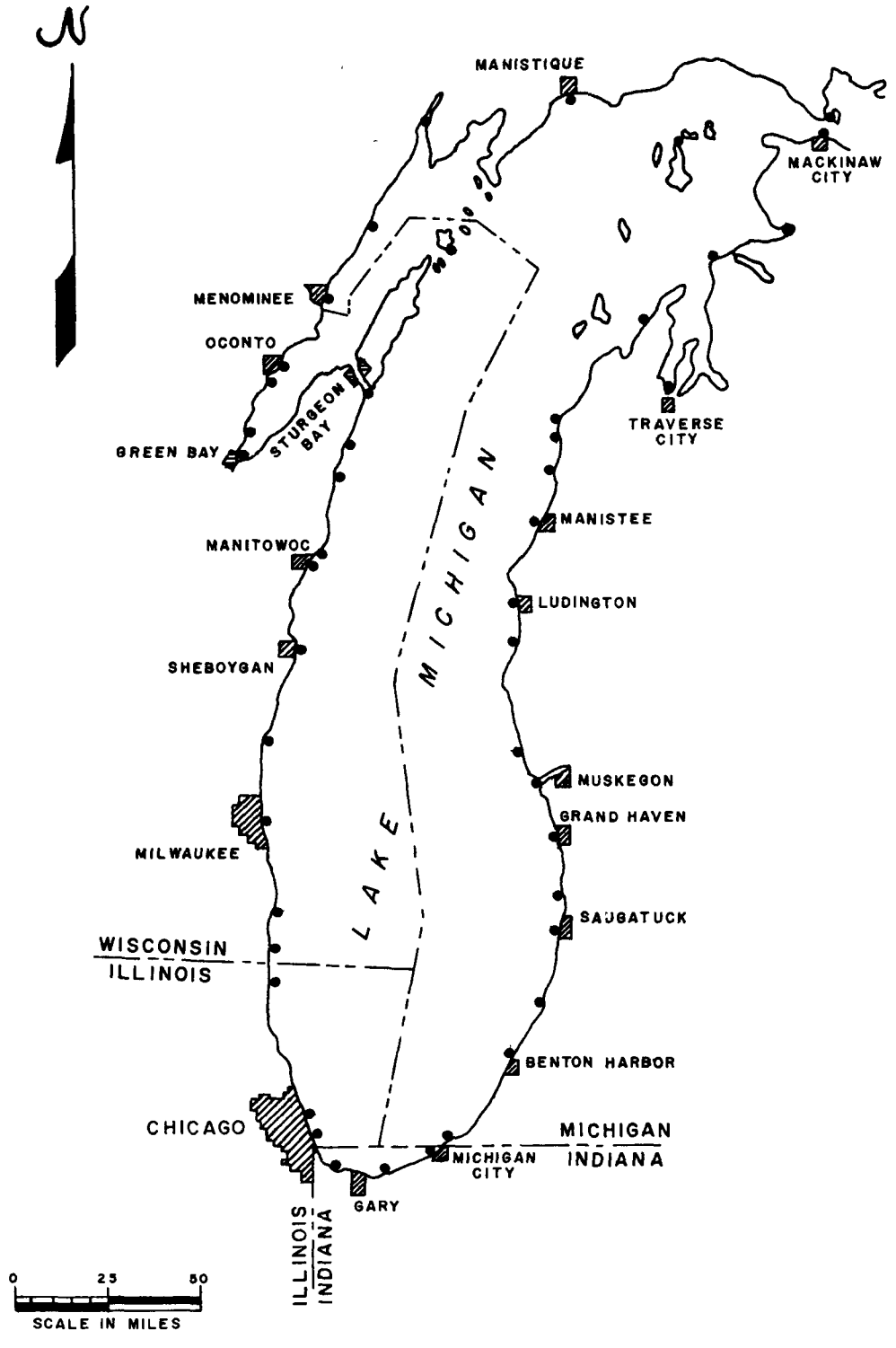
OIL DISCHARGES FROM OUTFALLS AND COMMERCIAL SHIPS
REPORTED BY THE U. S. COAST GUARD IN THE
LAKE MICHIGAN DRAINAGE BASIN IN 1967

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

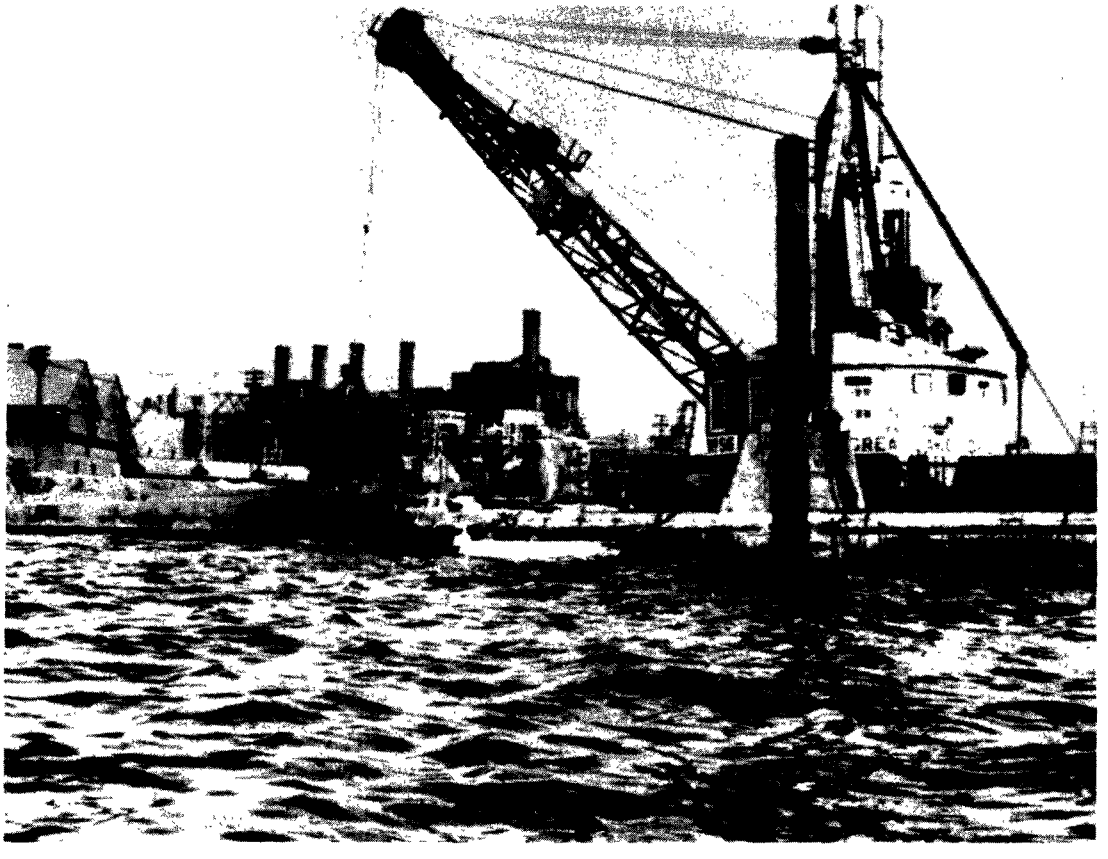
This aerial photograph shows a barge disposing of dredgings from the Indiana Harbor Canal in an authorized dumping area six miles out in Lake Michigan. This practice was halted shortly after this photo was taken, with the remainder of dredgings from the canal disposed of in diked-in lake fill areas.

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.

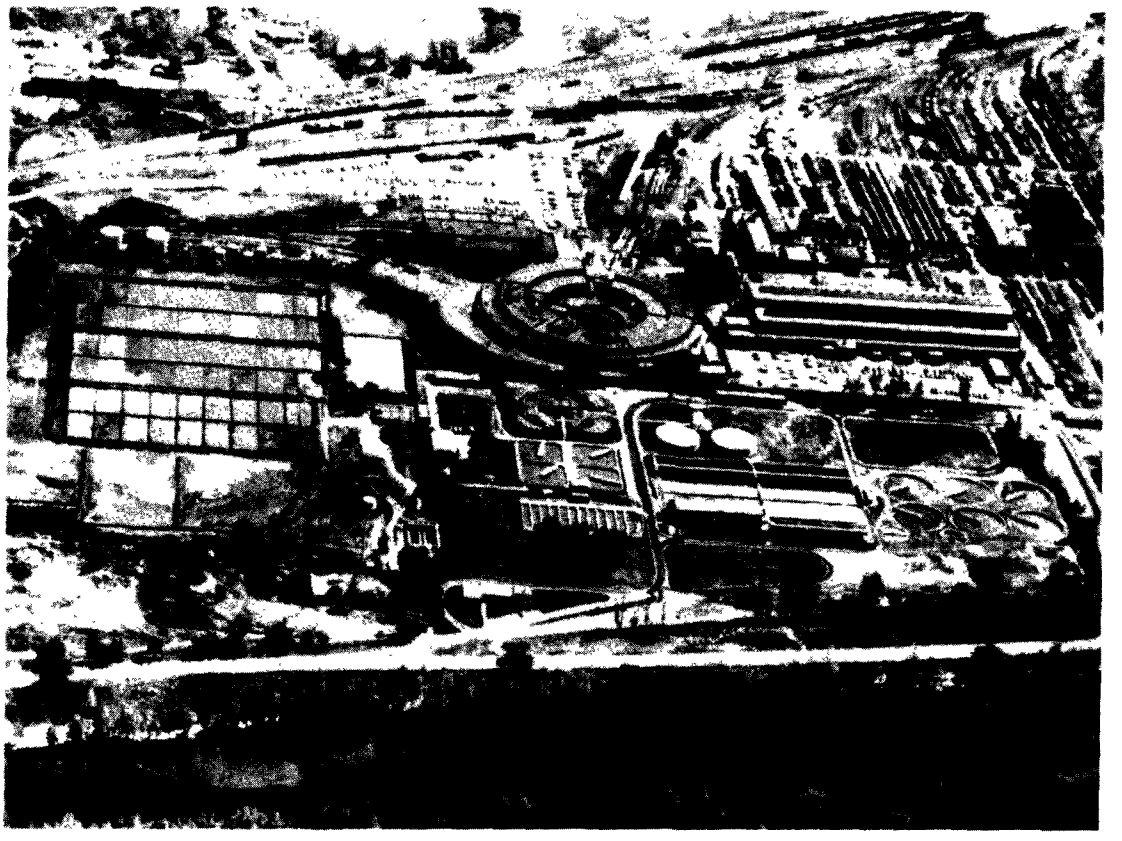
3. That the State of Illinois be given the responsibility for allocating the diversion.

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.

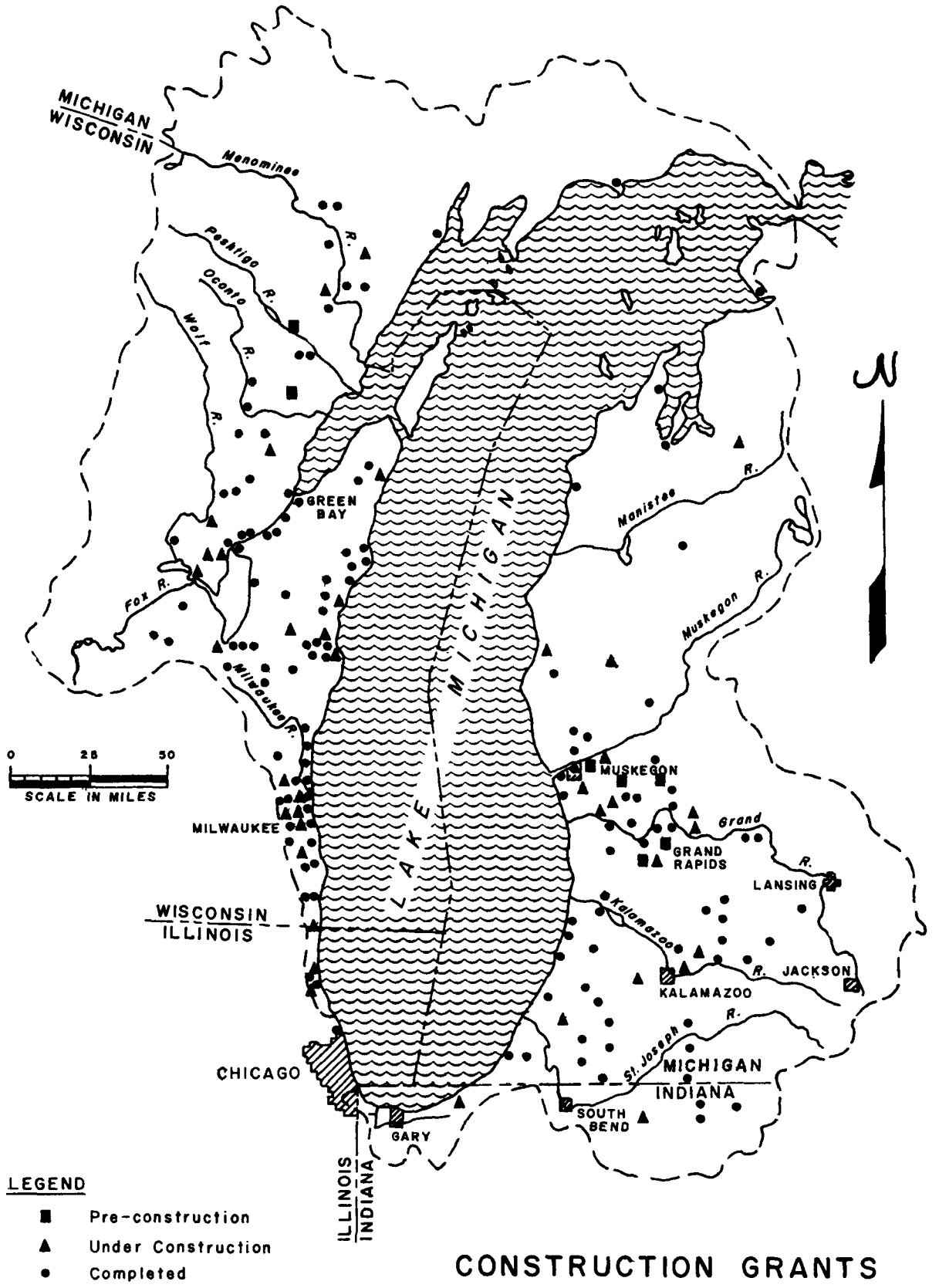
Since the 1956 Act, a total of 181 Federal grants have been made in the Lake Michigan Basin to help communities build needed sewage treatment facilities. (See Figure 9) Grant funds involved in these projects have totaled over $22 million in support of total project expenditures in excess of $86 million. 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.



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.

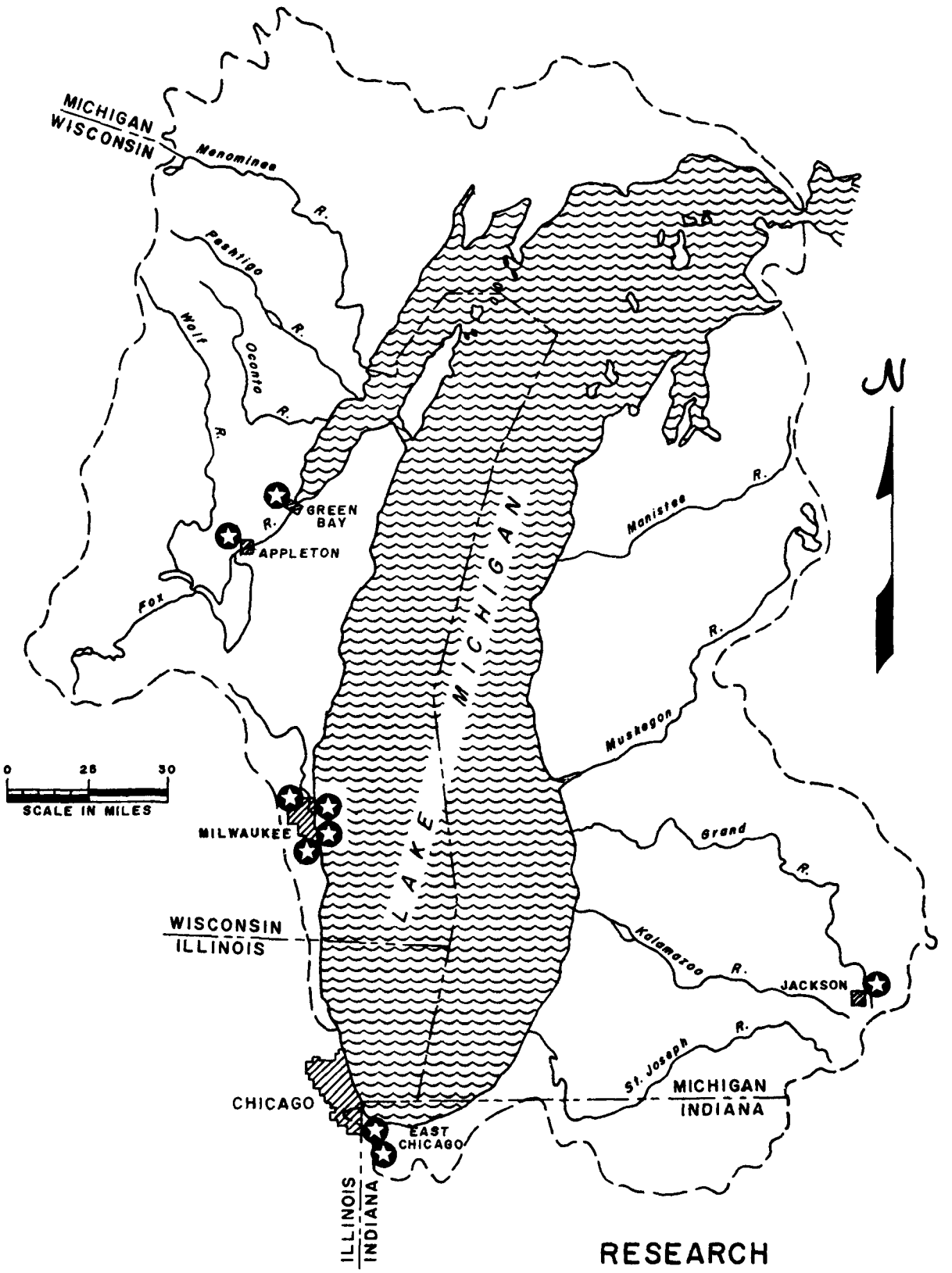
The Lake Michigan Basin has seven approved demonstration grants and two approved demonstration contracts in an active status. Applications for other possible grants are under review. Table 3 shows the present grants and contracts awarded, and Figure 10 shows locations.

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.

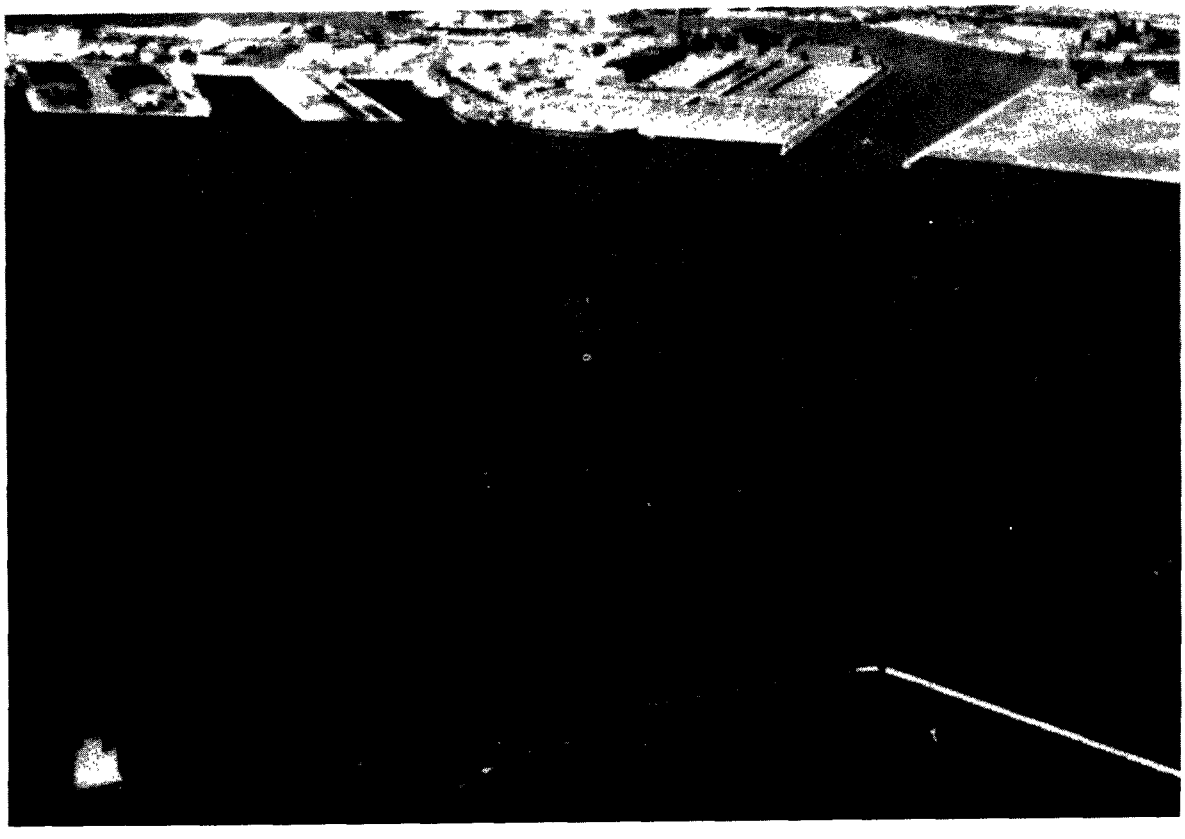
10-WIS-1 - Reduction of degree of pollution in the Milwaukee River is anticipated by increasing the efficiency of intercepting devices and by using a detention tank to capture and treat the storm overflow of combined sewage for an urban area comprising 570 acres which constitutes approximately 3 percent 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.

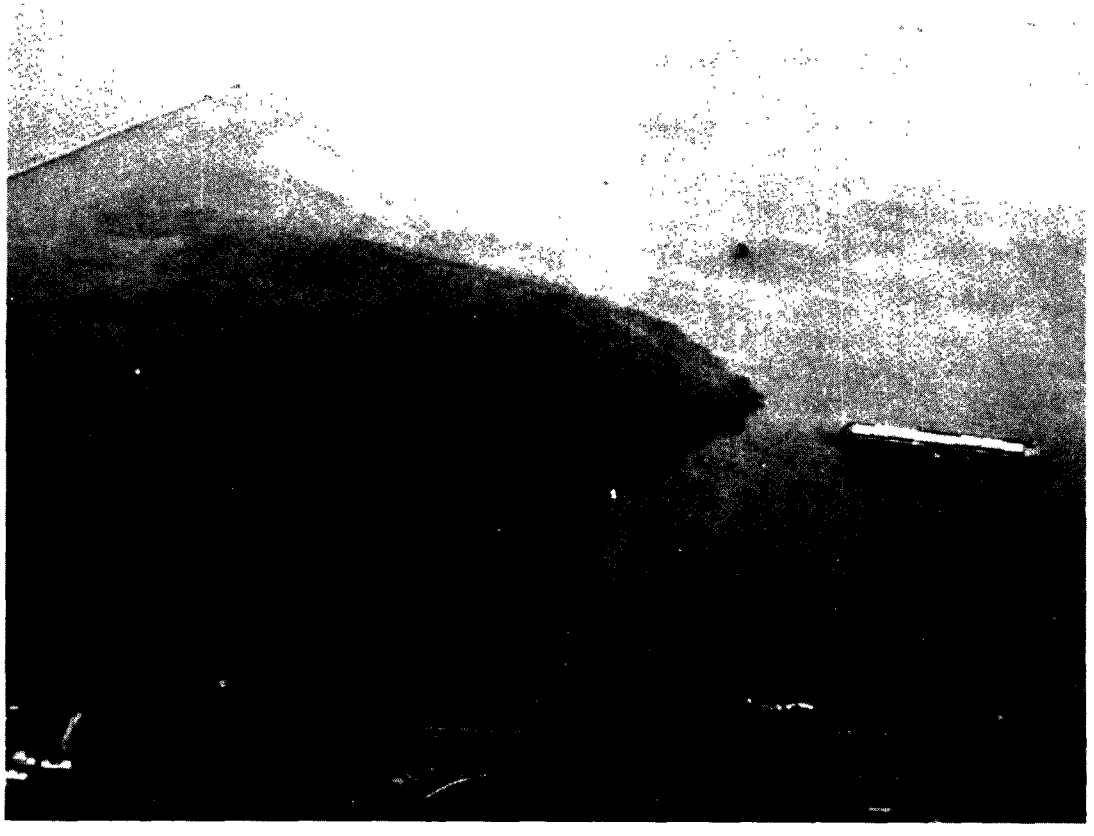
WPRD 60-01-67 - The project is a study, evaluation, and determination of the effectiveness, design, and operating parameters of four alternative biological treatment processes and modifications for treating combined municipal and industrial (primarily paper mill) wastewaters.

14-12-40 - This project will develop and demonstrate the applicability 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.

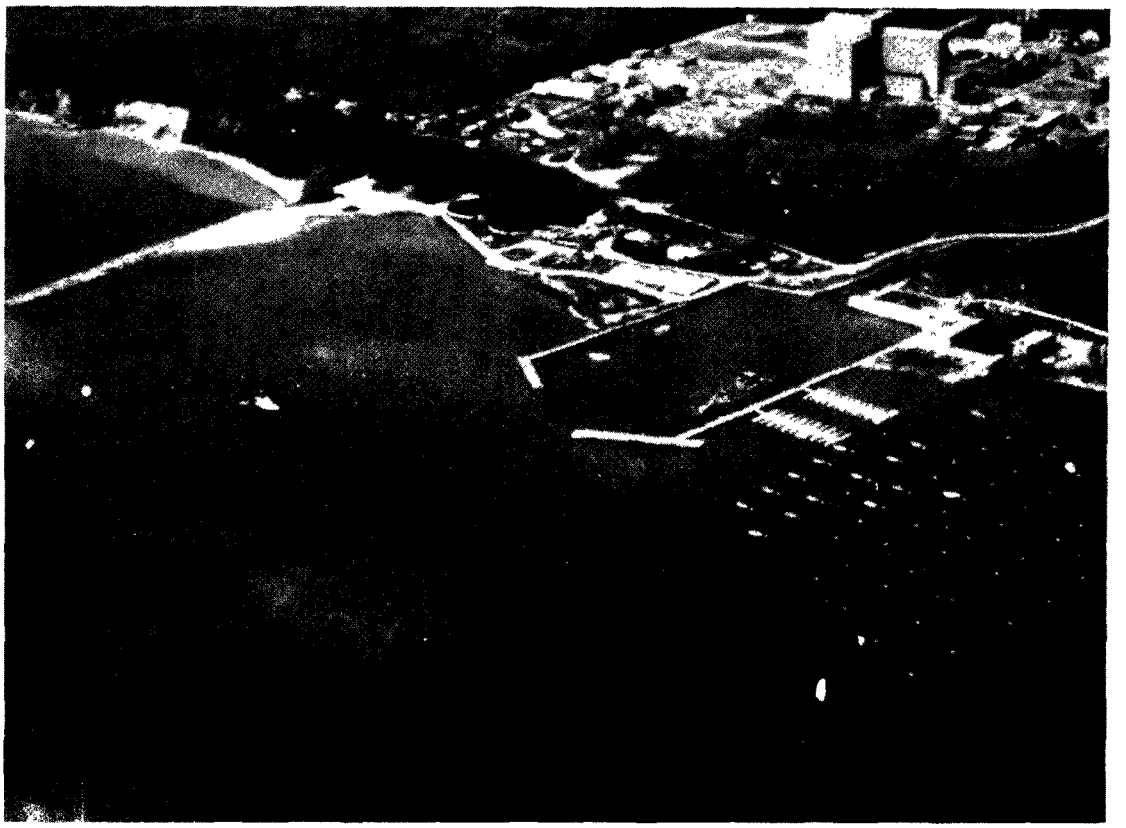
Federal Installations

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

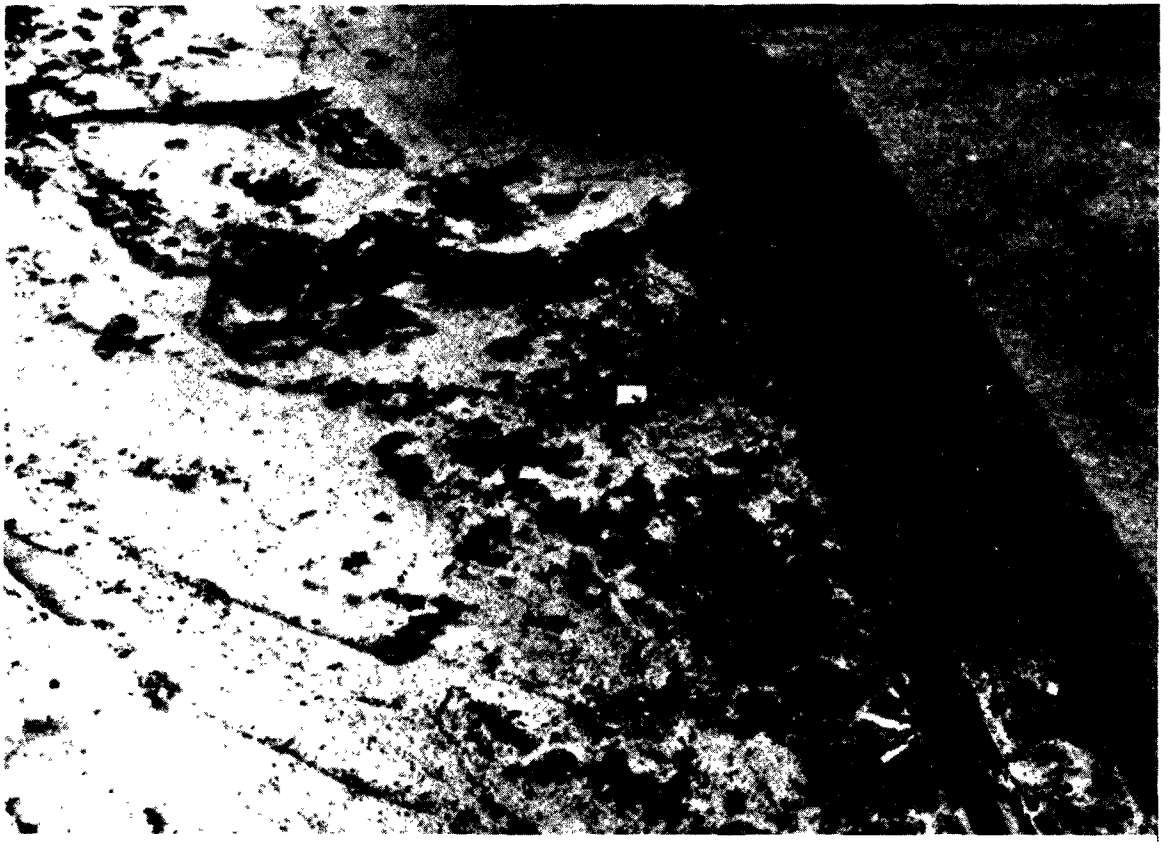
The Regional Technical Program provides technical assistance to States, local authorities, and industry upon request through the State water pollution control agencies, and to other Federal agencies. Current technical assistance projects in the Lake Michigan Basin include:

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

REFERENCES

1. United States Census of Population, 1960, U. S. Department of Commerce, Bureau of the Census.

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3. Lake Michigan Basin, Population and Economy, Federal Water Pollution Control Administration, Great Lakes Region, Chicago, Illinois.

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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
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^2 & 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		

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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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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	Rating	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	Rating	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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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	

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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.					
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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FEDERAL INSTALLATIONS LOCATED
IN THE
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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FEDERAL INSTALLATIONS LOCATED
IN THE
LAKE MICHIGAN DRAINAGE BASIN

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
IN THE
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		

MR. STEIN: We had better have the questions. I throw this open for questions.

MR. POSTON: Mr. Chairman, I would like to withhold the questions until we get through with Dr. Baumgartner and Dr. Weinberger.

MR. STEIN: I am not sure. I think they are quite different reports. I think if they want to ask questions I am going to ask that they ask them now on one segment at a time, because when you have a tremendous mass of technical information going in I think you lose sight of some of those after this material is presented.

So we will ask for comments or questions.

Mr. Klassen.

MR. KLASSEN: Mr. Chairman, I wondered whether questions on the recommendations are in order inasmuch as they haven't been recited here. My questions are about the recommendations.

If now is the time, I would like to make some comments on the recommendations and ask some specific questions. Do I do this now or after they are presented?

MR. STEIN: I think it might be more orderly for the recommendations to be presented

first. However, if you feel that raising this question now would help in the orderly presentation, you should ask it. We are going to have statements on eutrophication, we are going to have a presentation on currents, and we are going to have a presentation on nutrient removal. Now, the sooner we can come to grips with the issues, the better off we are going to be in an orderly presentation.

If you think that by raising the question now and that when we get that presentation these points might be covered, it might be well to raise it. This is up to you.

MR. HOLMER: Mr. Chairman, I would like to speak in support of Mr. Poston's suggested procedure. I think that having the eutrophication, nutrient removal and currents presentation by the experts before the recommendations would give us a more orderly view of this FWPCA report and lay a better foundation for our questions about the recommendations.

MR. KLASSEN: I will defer to that. You asked me whether it was going to help. It will help me, but I don't think it is going to

help you.

(Laughter and applause.)

MR. STEIN: Clarence, I have never found anything that didn't help you that helps me. What is good for Klassen is good for Stein and maybe even General Motors.

(Laughter.)

MR. POOLE: Mr. Stein.

MR. STEIN: Mr. Poole.

MR. POOLE: I concur in deferring questions and discussion on the conclusions and recommendations until they are presented. There are two or three observations in the report that Mr. Schneider has just covered that I would like to clear up.

One is on page 28 and 29 where he is talking of oxygen deficiencies. He says that there are severe oxygen deficiencies in the St. Joe River in Indiana and Michigan.

I checked our records for the last four years, day before yesterday at a sampling station close to the Michigan line, and the lowest dissolved oxygen that we got in 1966 was 6.2 parts per million; the next lowest

was 8.4; in the year of 1965 the lowest was 9.5; in 1966 the lowest was 8.8, and in 1967 the lowest was 8.5. I don't know what Mr. Schneider considers a serious oxygen deficiency, but I have not been accustomed to assuming oxygen levels such as that represented a serious oxygen deficiency.

Secondly, on the map showing the power stations--and as far as I know in all this history of Lake Michigan activity this is the only thing you have ever left out for the State of Indiana--there is another powerplant to the east of Gary that is owned by the Indiana-Michigan Electric, or Northern Indiana, that we call the Baileytown Generating Station. In other words, there are three powerplants in Indiana on the south end of Lake Michigan.

Finally, in the section on construction grants, which Mr. Schneider didn't dwell on, I think he has fouled this rather seriously or the report writers have in that they say there have only been five Indiana construction grants in the basin and they give a dollar figure; I have forgotten what it was. But

there have been 10 instead of 5 within the basin that received a total of a million and three-quarters dollars, and there have been another 8 on the Grand Calumet River and the Little Calumet River, the portions that flow west into Illinois, that received an additional million nine hundred thousand dollars.

I guess I am making this statement largely in defense of the Indiana group because I don't want the Hoosiers to say or I don't want you people here to think that none of Indiana's construction grant money is going into the Lake Michigan Basin.

This is all I have except for when we come to the recommendations.

MR. SCHNEIDER: Well, I am glad to hear that there has been more Federal money in the Lake Michigan Basin, and if our report is wrong, we will check this out and make corrections in it.

MR. STEIN: Let us try a compromise ruling on this. I think, as you see, these people have some questions dealing with clarification questions. Now, if those are

clarifications, I suspect they will be in this portion of the report, or comments, we will take the clarification items because that can't be put aside and we will defer the other questions until after the recommendations are in.

Are there any other comments of that nature, of clarification?

MR. OEMING: I do.

MR. STEIN: Mr. Oeming of Michigan.

MR. OEMING: Mr. Chairman and Mr. Schneider, some of the questions I have go to the body of the report itself and not the conclusions section. But if you feel that some of these questions should be deferred and answered by someone else, I hope you won't hesitate to say so.

First of all, I would like to ask a question about back under "Bacterial Pollution" on page 25. I think this applies not only to what I am talking about in Michigan, but also with respect to the other tributaries.

My first question, then, refers to bacterial pollution in the Grand River in

Michigan, and I would like to know what the effect of that is upon Lake Michigan. Let's assume, for instance, and I suspect you might be talking about the lower Lansing, but it is some distance from Lake Michigan. Now, what is the residual effect of that bacterial pollution on Lake Michigan? Does this have an impact?

MR. SCHNEIDER: I wouldn't think it would that far from the lake.

MR. OEMING: Now, with respect to page 29.

Here you specified certain periodic oxygen deficiencies in the Grand River downstream from Jackson and Lansing. This is not an issue; certainly there is.

Again my question is, what is the significance of oxygen depletion some 80 miles, perhaps, from Lake Michigan on Lake Michigan itself?

MR. SCHNEIDER: There perhaps would be none that distance from the lake.

MR. OEMING: I see.

Now, on page 29 you mentioned

deficiencies in the Kalamazoo River, and I think you are referring there to below Kalamazoo. Could you tell us what your most recent information is about this? Could you specify as to about the period you are talking about up to date on this?

MR. SCHNEIDER: I believe the information that we had was taken from a report from your own agency, and I think it was about three or four years ago.

MR. OEMING: That is the point I am making.

MR. SCHNEIDER: And we realize now that there has been an improvement in the Kalamazoo River below.

MR. OEMING: This situation may not apply today or this coming summer.

MR. SCHNEIDER: That is right.

MR. OEMING: All right.

Now on page 30 you mention two problems from power plants and particularly cite added heat and the discharge of waste radioactivity. Are you concerned about the solids that is from the ash from fossil-fueled

plants--using coal I am speaking of--are you concerned at all about the ash waste problem, the solids?

MR. SCHNEIDER: We haven't been taking it up in the report, but that could be a problem depending on--

MR. OEMING: I am asking this question because if it is concerned, then I think that the Conferees will need to take it into account, but if you don't feel it is a problem then I don't--

MR. SCHNEIDER: You mean as a water pollution problem?

MR. OEMING: Yes.

MR. SCHNEIDER: We would hope that it won't be discharged to the lake.

MR. OEMING: My point is that you didn't mention it, so I want to know if you felt it was a problem or you felt it wasn't a problem. If you felt it was, why it wasn't mentioned.

MR. POSTON: Mr. Chairman, I don't think that we have any power plants that discharge ashes or flue dust to the lake, to my

knowledge. I certainly am aware that this has been talked about and attempted by others on the lake, and I know that your position in Michigan is that you do not want to have anything like Lake Erie we have talked about concerning discharge or dumping of 300,000 tons a year of ashes to Lake Erie. Certainly we feel the same about Lake Michigan, that we should not use the lake as a discharge or a dump for cinders from fossil-fueled plants.

MR. OEMING: I just want to make sure that Michigan is asking something that you can subscribe to as to solids.

Now with respect to oil pollution, you covered the practices pretty well of discharges from vessels in transit or unloading docks and such matters, but I would like to bring up the question here as to whether you feel any concern about sunken vessels in the lake which may contain polluting materials that can subsequently be released through wind and wave action or breakup of the vessel. I have in mind a specific case, the Vessel Morazon at South Manitou Island in the middle of Lake

Michigan. The Morazon was sunk several years ago.

Investigations by the Michigan Water Resources Commission jointly with the Corps of Engineers has established the fact that there are 6,500 gallons of bunker sea fuel oil on that vessel. Now, the concern here is with the potential when this oil is released by the forces of nature, and all of the activities that Michigan has pursued and with the assistance of the FWPCA in Chicago, the Regional Office, have resulted in a warning to the owner of this vessel that should the oil escape he would be subject to penalty.

Now, I am not so much concerned about penalty as I am about the fact that once that oil gets in the lake, then we have a lot of trouble, and penalties don't help clear up that beach, those beaches on Lake Michigan.

MR. POSTON: Mr. Chairman, Mr. Cook of our Regional Office, Mr. Grover Cook, has worked on this particular problem and I think he may have a solution to this problem.

Mr. Cook, would you care to talk to

this point?

MR. STEIN: Would you go up to the lectern, Mr. Cook?

MR. COOK: This was brought to our attention, the Morazon, about September, I believe, of last year--Mr. Oeming probably has the date in front of him; I am not sure when it was--by the Michigan Water Resources Commission. We understood at that time that the owner was not known, that some Lansing corporation owned the ship.

It is a very interesting story, incidentally, I found out later after trying to dig into the details of it. It sailed out of Chicago on a bright sunny day with a calm sea and went off course about 30 miles onto a shoal. The skipper's wife was pregnant, there was a lot of canned chicken aboard, and the shipper in San Francisco wired the skipper and said, "Give your wife all the canned chicken she wants."

(Laughter.)

Of course it was under water.

Well, the ship became a problem of

concern to the people of South Manitou Island and the shore of Lake Michigan in that area, and we tried to find out what we could. First of all, we had to find the owner.

It took me about a month to find the owner, and I happened to find him because I heard that he was a junk dealer in Lemont, Illinois, and one afternoon I had to give a talk out by Lemont so I went down looking around for junk dealers and I spotted him. His name was Ralph Hicks and he had two partners whose names I don't recall.

I called him on the telephone, I couldn't find him in person, so I called him on the telephone and informed him that if that oil leaked out he would be in violation of a Federal law and subject to a rather severe penalty. He expressed his concern. In fact he said, "I have been watching this oil pollution thing on the television; I have been waiting for you to call."

(Laughter.)

So he was concerned and he told me that he was negotiating with a barge line to

have the oil off-loaded the next time a barge that was partly empty or empty went by that way. I think it was--I am not sure, I don't recall the barge line.

But I followed that up with a letter; a copy went to Mr. Oeming--I think you have it with you, probably--warning him the same warning that I gave over the telephone. I also got in touch with the Corps of Engineers Office in Detroit. They inspected the ship and reported to me that the deck was about 10 feet above waterline. There was one bunker that was empty; apparently somebody had off-loaded that or it had left Chicago with a very light cargo of oil. In fact, the agent for this ship, former agent, told me this probably is the case.

The Coast Guard was asked to look into it to make an inspection to determine whether or not there was a possibility of this ship capsizing or slipping off the shoal and spilling the oil. They did this and reported to me that there wasn't a chance of this thing slipping off that shoal or capsizing; it was

high and dry. The Corps of Engineers in Detroit also investigated, inspected the ship. They have been doing this routinely since that time.

The owner, Mr. Hicks, was unable to get the thing off-loaded before the winter weather hit, and I have been in touch with him as recently as a month ago. He can't do a thing until the ice breaks up, but he is going to attempt as soon as the ice goes out and the spring storms abate to get in there and get the stuff out.

In addition, there is absolutely no danger of this oil causing any problem, I understand from the American Petroleum Institute. In fact, Russell Mallatt, American Oil Company, told me the same thing. This stuff congeals in this cold water so that you have to use a steam lance to loosen it up to pump it out. It is like jelly. So there wouldn't be much of a chance of any oil pollution at this time and probably not until the water warms up to its usual 60 or 65 degrees in that area.

We certainly intend to get this thing taken care of as soon as possible.

MR. STEIN: Thank you very much.

Are there any further comments or questions at this time?

MR. HOLMER: I have several questions, if I may.

MR. STEIN: I believe Mr. Oeming still has the floor.

MR. HOLMER: Oh, sorry.

MR. OEMING: Mr. Schneider, could you tell me when that picture of the foam in the Grand River below Jackson was taken?

MR. SCHNEIDER: Last summer some-time.

MR. OEMING: Last summer. O. K.

I think that concludes the questions I have.

MR. STEIN: Mr. Holmer.

MR. HOLMER: Yes, sir.

My first couple of questions are purely informational.

With respect to the drainage basin, the extent of it in the State of Illinois, you indicate less than one percent. Is all of the storm water of Chicago captured and sent on down to St. Louis?

MR. SCHNEIDER: I believe there is a small portion that does get into the lake.

MR. HOLMER: But was that computed in this less than one percent land area that is referred to in the report?

MR. SCHNEIDER: Probably not.

MR. HOLMER: I am not sure how significant this is. One of the slides you showed was a picture of the water intake for the City of Chicago, and this takes in a rather substantial amount of water daily and treats it for distribution. What is done with the backwash from this treatment plant?

MR. SCHNEIDER: Well, I understand that it is discharged directly to the lake.

MR. HOLMER: Well, we will wait for Illinois to comment on what plans they may have with respect to that.

You indicate that the present usage

of water in Lake Michigan is at 4.25 billion gallons per day, 80 percent of this usage by industries. Does that include the withdrawal of the waters from Lake Michigan by Chicago?

MR. SCHNEIDER: No, I think that figure is strictly for the Indiana industries.

MR. HOLMER: Well, the total was listed as 4.25 billion gallons and 80 percent was charged to Indiana for industrial use?

MR. SCHNEIDER: Yes.

MR. HOLMER: What percentage of that use is consumptive as opposed to collection use and then discharged back to the lake? Do we have any figures on that?

MR. SCHNEIDER: I don't think we do.

MR. HOLMER: Would it be your guess that most of that is returned to the lake in one condition or another?

MR. SCHNEIDER: I would think--

MR. POSTON: I would say that all of the City of Chicago water supply, which I think in the diversion case is some up-to 1,500 second feet, goes down the Chicago River with

Chicago wastes.

MR. HOLMER: I am curious as to whether this is in addition to this 4.25 billion gallons that were cited in the report.

MR. POSTON: I think I will have to get that figure for you.

MR. SCHNEIDER: We can get that.

MR. HOLMER: Well, I think it is a fairly significant figure in connection with some proposals which are sometimes made with respect to lack of treatment of waste water in other sections of the basin and also the matter of consumptive use by industry so that we get some idea of what the loss to the basin is.

MR. STEIN: I think that is a good point.

Can we have that question clarified after lunch?

MR. SCHNEIDER: Yes.

MR. STEIN: And as soon as we come back, Mr. Holmer, I think we will try to get you a complete answer to that question. That is a very good point.

MR. HOLMER: My next question has to do with waste discharge, and I did not hear when Mr. Poston was listing the Federal spokesmen that any representative of the Atomic Energy Commission was planning to be present. Is there a plan to have such a representative here?

MR. POSTON: Mr. Holmer, our people tell me that Chicago public water supply, which is, as I indicated, about 1,500 second feet, is not included in this 4.25.

MR. HOLMER: It is not included. And then the diversion water is in addition to that?

MR. POSTON: Yes, it would be.

MR. STEIN: Is that a fair statement? You had better take your time on this one and let's get this definitively after lunch.

But there is another question of Mr. Poston, the question that Mr. Holmer raises, is a representative of the Atomic Energy Commission going to make a statement at this conference, to your best knowledge and belief?

MR. POSTON: Not to my knowledge.

MR. STEIN: Were they invited?

MR. POSTON: Yes, sir.

MR. HOLMER: My next question has to do with the Chicago City ordinance to which reference is made with respect to handling of pollution from vessels. Will copies of that ordinance be available to the conferees? Is this a possibility?

MR. POSTON: We can get you a copy of that ordinance.

MR. HOLMER: Still another question has to do with the three million tons of sediment which are annually contributed to the waters of the basin. Do we have any estimate of how much of this is natural sedimentation rather than sedimentation from man-made sources?

MR. SCHNEIDER: I think this was computed on the basis of the runoff from some selected watershed areas, so it would represent--this is an estimate--it would represent the agricultural runoff.

MR. HOLMER: In other words, this sedimentation is almost entirely--well, this is a watershed area--excuse me, I had better

rephrase the question.

We know from studies which have been made that sedimentation from forest lands is rather substantial, but not as substantial as sedimentation from agricultural lands, and we know that land under construction produces still a much larger per square acre contribution to the sedimentation problem. And I am curious for this whole basin whether three million tons of sediment represents 2.7 million, for example, that is uncontrollable, or 1.2 million tons that is uncontrollable. Is this, in other words, a matter within the provinces of this conference really to come to grips with, in an effective way?

MR. SCHNEIDER: Well, I think this was one of the problems that we pointed out, and I think that the principal responsibility for controlling that would have to rest with the agricultural agencies.

MR. HOLMER: I won't ask whether the coordinated effort to get the Federal house in order is fully budgeted and scheduled, but I would like that information at an appropriate

time.

And I have one further question that you may wish to defer to Mr. Bathurst on, and that is whether the FWPCA has sought to initiate action by the Department of Agriculture or in any other way to propose that the use of chlorinated hydrocarbons be discontinued entirely.

MR. SCHNEIDER: I don't think there has at this time.

MR. HOLMER: Thank you.

That is all I have, Mr. Chairman.

MR. STEIN: I think Mr. Oeming has another question.

MR. OEMING: Mr. Schneider, would you please refer to page 28 under "Oxygen Depletion," the last paragraph on the page?

In your summary of your findings I believe you omitted the significant statement that is of interest to the conferees and the people here as well as to the oxygen conditions in Lake Michigan. Was there any reason you omitted that?

MR. SCHNEIDER: I didn't catch that.

MR. OEMING: I think you omitted the

first sentence in the last paragraph with respect to the oxygen conditions in Lake Michigan when you were reviewing the report. It seems to me that is an important consideration for the conferees as well as the interested people here in this audience.

MR. SCHNEIDER: Well, that would have been covered in the conclusions.

MR. OEMING: Would you please read the statement?

MR. STEIN: Do you want him to read the sentence?

Do you want to read it?

MR. SCHNEIDER: "At present, the main body of Lake Michigan has not shown signs of oxygen deficiency--"

MR. OEMING: That is not all the sentence, is it?

MR. SCHNEIDER: --"even in its bottom waters, where an oxygen deficit is frequently observed in eutrophic lakes and in manmade reservoirs."

MR. OEMING: Thank you very much, Mr. Schneider.

R. J. SCHNEIDER

MR. STEIN: Are there any further comments or questions?

Gentlemen, I believe it has been indicated here that a questioning of this type at this time has the advantage of giving us a leadtime in getting some answers when we are preparing a comprehensive report. For example, the question that Mr. Holmer has and the question on that ship, we had to get our specialists to dig up the answers. I think this has some advantages over waiting to the end, because we lose our leadtime and we can't locate the specialists that can provide the information we need.

Are there any other comments or questions?

MR. OEMING: Well, along the same lines, and the point that I wanted to nail down on this ship business was, do you feel, Mr. Schneider, or does the FWPCA feel that the mechanisms are available to handle situations like this without any further consideration by the conferees? I think that is the basic question.

MR. SCHNEIDER: Again I didn't hear

the first part of your question.

MR. STEIN: The question is whether we have sufficient mechanisms to handle sunken ship situations without further consideration by the conferees.

MR. SCHNEIDER: I would say that at the present time there could be additional measures taken in cases such as you mentioned.

MR. OEMING: I see. Thank you.

MR. STEIN: Are there any further comments or questions?

If not, let us recess for 10 minutes, and let's get back promptly because we are going to run until 12:30.

(Recess.)

FEDERAL PRESENTATION (CONTINUED)

MR. STEIN: May we reconvene, please.

We would like to reconvene. Those in the back either take seats or continue their conversations in the corridor and not the anteroom.

We understand that there are several people in the audience who would like to make statements. I will be glad to repeat the announcement that was made yesterday. You should get in touch with your State agency for an appropriate place on the schedule. Each State will manage its own time, and after the next recess you should see your respective State representatives.

Mr. Poston, would you continue with the presentation.

I do understand there have been also some complaints that people in the back cannot hear the conferees. We would recommend that the conferees speak into the microphone and stay rather close to it. If there is any further problem in hearing in the rear of the room, if you people would just raise your hands, maybe we will be able to correct it.

FEDERAL PRESENTATION (CONTINUED)

MR. POSTON: Our next presentation will be by Dr. Alfred Bartsch, our Senior Eutrophication Scientist. I think he may bring out some facts having to do with effects of inland contributors of pollution which may be quite some distance from our Lake Michigan, conditions which do affect the lake from a considerable distance. I think Mr. Oeming established the fact that wastes from Lansing did not contribute bacterial pollution to Lake Michigan and that oxygen depletion didn't extend from Lansing down as far as Lake Michigan.

There could be other effects from pollutional materials from Lansing that do affect Lake Michigan, such as our nutrients, ammonia or methane or products that might exert an effect on the lake.

I will ask Dr. Bartsch to proceed.

DR. A. F. BARTSCH

STATEMENT BY DR. A. F. BARTSCH
CHIEF, NATIONAL EUTROPHICATION RESEARCH PROGRAM
PACIFIC NORTHWEST WATER LABORATORY
FWPCA, CORVALLIS, OREGON

DR. BARTSCH: Chairman Stein, conferees, ladies and gentlemen.

I was impressed yesterday by Dr. Yoder's comments in which he compared the aging processes in lakes with the aging processes in the human body. I thought this was a fairly unique approach.

In my statement this morning on conditions of the eutrophication of Lake Michigan, I want to explore with you some of the symptoms of aging in Lake Michigan that are now occurring.

Through vigorous efforts of the press, thousands of people living in the Lake Michigan watershed are acquiring an awareness of the term "eutrophication." They are learning, also, that it relates in some manner to water pollution and water quality problems in the lake.

On the technical side, many scientific

studies of Lake Michigan have been carried out over the years by a number of agencies representing States and communities fronting on the lake. The resulting observations cover a historical period dating back before the turn of the century, but the data improve in completeness only in recent times. Among recent Lake Michigan studies, one needs to cite the intense efforts of the Great Lakes Research Division of the University of Michigan --you may recall that Exhibit No. 1, if I am correct on the number, was a voluminous report covering some of this work --the Center for Great Lakes Studies of the University of Wisconsin, and the studies of the Great Lakes Region of the Federal Water Pollution Control Administration. Out of these studies has come one report, which, Mr. Chairman, I would like to introduce as an exhibit for the record of this conference, in part because this is part of the basis for some of the comments which I will make. This report is titled, "Water Quality Investigations, Lake Michigan Basin, Biology." It is dated January 1968, was prepared by Great Lakes Region of the

DR. A. F. BARTSCH

Federal Water Pollution Control Administration.

MR. STEIN: Without objection, that will appear in the record as if read.

(Which said report follows:)

LAKE MICHIGAN BASIN

BIOLOGY

A TECHNICAL REPORT CONTAINING BACKGROUND DATA

FOR A WATER POLLUTION CONTROL PROGRAM.

FEDERAL WATER POLLUTION CONTROL ADMINISTRATION

GREAT LAKES REGION, CHICAGO, ILLINOIS

JANUARY 1968

WATER QUALITY INVESTIGATIONS

LAKE MICHIGAN BASIN

BIOLOGY

A technical report containing background data
for a water pollution control program.

January 1968

UNITED STATES DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
Great Lakes Region Chicago, Illinois

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FOREWORD

The study of the biology of the Lake Michigan Basin was conducted under the administrative guidance of H. W. Poston, Regional Director, Great Lakes Region, FWPCA. Sample collections and analyses and data compilation and organization were made by regional personnel. Final draft of the report was prepared by biologists of the Technical Advisory and Investigations Branch, FWPCA, Cincinnati, Ohio.

SUMMARY AND CONCLUSIONS

1. The biota of the mid-water area of Lake Michigan reflects an unpolluted environment. Free floating algal populations were less than 500 per milliliter. Pollution-sensitive scuds predominated in the bottom associated organism population. Sludgeworm populations were less than 1,000 per square meter and midges were principally of the clean water variety.
2. Extensive inshore areas of pollution totaling 3,475 square miles were found along the entire southern perimeter of Lake Michigan specifically Milwaukee, Racine and Chicago-Calumet and in Green Bay. The loss of the Green Bay fly, a fish food organism, and other detrimental pollution associated conditions have impaired commercial fishing in Green Bay. Swimming beaches have been closed in Milwaukee, Chicago and other areas when large mats of foul smelling algae have been deposited on the beaches. Aesthetic values associated with water have been impaired by algae on many occasions. Short filter runs and taste and odors resulting from high

phytoplankton populations have increased the cost of water treatment at Green Bay, Milwaukee, Kenosha, Chicago, and other cities.

3. Other more localized inshore areas of pollution totaling 350 square miles resulted in increased sludgeworms and free floating algal populations offshore from: Manitowoc, Sheboygan, Port Washington, Benton Harbor, South Haven, Saugatuck, Grand Haven, Muskegon, Ludington, Manistee, and Manistique.

4. Pollution of inshore areas: supported pollution-tolerant sludgeworm populations exceeding 1,000 per square meter; suppressed gamefish food organisms; supported nuisance algal populations exceeding 500 per milliliter and as high as 20,000 per ml. in Green Bay; produced dense growths of attached algae in shallow water areas that break loose and become deposited on swimming beaches. Soluble phosphate (PO_4) concentrations averaged 0.04 mg/l with values as high as 5.0 in these areas. These concentrations exceed the adopted standard of an annual average total phosphate (PO_4) of 0.03 mg/l and a single daily average or value of 0.04 mg/l.

BIOLOGICAL EFFECTS ON WATER USES

The biological examination of waters and bottom materials incorporates both a qualitative determination of the kinds of organisms present and a quantitative estimate of their numbers or bulk. This information aids in the interpretation of physical and chemical analyses, indicates pollution by wastewaters, determines the progress of self-purification within the waterways, assists in the limnological study of the environment, measures damages inflicted on aquatic life and water use potentials, and indicates impact of nuisance organisms on water uses.

Suspended microscopic plants (algae) are the primary convertors of light energy to organic matter; they are the original source of most of the food that nourish fish and other aquatic animals. Changes in the physical and chemical properties of the water affect both algal quantities and species composition. When the quantity of fertilizing nutrients increases, the number of algae will increase and the species composition will change. Dense green algal populations reduce the aesthetic

values of a water and interfere with water uses such as boating and swimming. Windrows of dead and odoriferous decaying algae are nuisances and obstruct uses at beaches and surrounding lands. Changes in both the concentration and relative composition of the fertilizing material produce detectable changes in the species composition of the algal populations. High concentrations of phosphorus favor the blue-green algae which are capable of using nitrogen from the atmosphere as a source of nitrogenous nutrition; these algae are particularly obnoxious because they are more buoyant than other forms thus tending to form windrows more readily and produce especially obnoxious "pigpen" odors because of chemical compounds peculiar to them.

Bathing beaches have been closed for extensive periods near Milwaukee, Chicago and other localities because of rotting foul-smelling algae and dead fish, and threats to public health from water contaminated by sewage. A seemingly inexhaustible supply of algae that has washed ashore in recent years has defied maintenance attempts to keep some beaches usable during the recreational period. Bathers and sun-bathers must travel farther to enjoy their sport. The aesthetic beauty of Lake Michigan has been severely impaired.

Excessive quantities of algae in Lake Michigan have caused short filter runs in water treatment plants. When the runs are shorter than 20 hours, the result is a loss in revenue because of loss of plant capacity and the use of larger amounts of wash water. Kenosha, Wisconsin obtains its water supply from an intake pipe extending 4,200 feet into Lake Michigan to a depth of 30 feet and has experienced three-hour filter runs in recent years along with taste and odor problems. Because algae and other microorganisms are implicated in both of these water supply problems, Kenosha in 1961 installed four microstrainers at a cost of $330,000 to reduce the number of microorganisms. At this time Kenosha was receiving as much as 450 pounds per day of wet algae through the water intake pipe. Following microstrainer installation, that resulted in 90 percent algal removal, taste and odor problems disappeared and filter runs increased to an average of 48 hours. Problem algae were: Stephanodiscus, Tabellaria, Asterionella, Synedra, and others.

At Green Bay, Sheboygan, Milwaukee, Waukegan, Evanston, Chicago, Gary-Hobart, Michigan City, Benton Harbor, Holland, Grand Rapids, and Musekgon, 37 percent of filter runs were less than 20 hours in 1961.

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Bottom animals serve as a vital link in the aquatic food web by converting plant food into animal food for predatory fishes. Changes in numbers of bottom animals and in composition of the bottom-animal community produce changes in the fish population. For example, a community consisting predominantly of burrowing worms favors a community of fishes such as carp and suckers that root for their food. An increase in worms is a product of an increased food supply from sedimentation of organic waste materials or dead algae. Changes in the kinds and numbers of bottom animals are effects that are frequently a product of pollutants; these changes result in damages to desirable aquatic organisms, and may produce increased numbers of undesirable aquatic organisms that interfere with and reduce the uses that can be made of the waters.

Environmental changes resulting from pollution eliminated the burrowing mayfly (Green Bay fly) from major sectors of Green Bay in recent years. Concurrently commercial fishing was severely impaired, thus affecting another water use by disrupting the aquatic food web.

MID-LAKE AREA RESULTS

The deep-water areas of Lake Michigan are presently unaffected by the pollution observed in many areas closer to shore. Soluble phosphate (PO_4) averaged 0.02 milligrams per liter (mg/l) in deep water areas with some values as high as 0.14 mg/l. Inshore areas averaged 0.04 mg/l PO_4 with values as high as 5.00 mg/l. Adopted water quality standards for Lake Michigan open water and shore water limit annual average total phosphate (PO_4) to 0.03 mg/l and a single daily average or value to 0.04 mg/l. Obviously these standards are now exceeded in some areas and high nutrient concentrations are reflected in increased biological growths. Inorganic nitrogen averaged 0.19 milligrams per liter in deep-water (ranging as high as 1.15) compared to 0.27 milligrams per liter inshore (ranging as high as 2.2 near Milwaukee). The distribution of populations of benthic animals and phytoplankton generally reflects the pattern of distribution of soluble nutrients.

With one exception, the population of bottom organisms decreased with increasing depth (Table 1). In the deepest

area (260-269 meters) there was an increase in the population of all organisms to 5,000 per m^2; this is characteristic of organism population distribution in many deep lakes. Scuds of the genus Pontoporeia, are pollution-sensitive organisms; they were the predominant bottom-associated organisms in areas not greatly influenced by organic sediments.

The population of scuds in much of the deep central basin numbered less than 1,500 per square meter (Figure 1). There is a combination of depth dependent factors such as sediment types and nutrient content that limits scud populations in depths greater than 50 meters. In the deep central areas of the lake sludgeworm populations numbered less than 1,000 per square meter. This relatively low population of sludgeworms as shown in Figure 2 indicates an unpolluted environment. The midge larval population in the central section of Lake Michigan averaged 37 per square meter and was composed of 84 percent clean-water species and no pollution-tolerant species with the remaining being of variable tolerance. This further indicates the unpolluted condition of the sediments of the central basin.

The deep-water areas of Lake Michigan supported planktonic algal communities of low population density that generally ranged from 100 to 300 organisms per milliliter (Figure 3). Conversely, nutrient-enriched inshore areas supported larger

populations of phytoplankton, generally numbering more than 500 organisms per milliliter.

For many years, the planktonic algae of Lake Michigan have been dominated by the genera Tabellaria, Asterionella, and Synedra. These forms are found in nonfertile lakes. However, pollution of Lake Michigan has caused Cyclotella and Stephanodiscus to become the predominant forms in most samples; even in samples in which Asterionella, Tabellaria and Synedra predominated, Cyclotella and Stephanodiscus usually were abundant. Table 2 lists the genera of phytoplankton most commonly encountered in Lake Michigan waters.

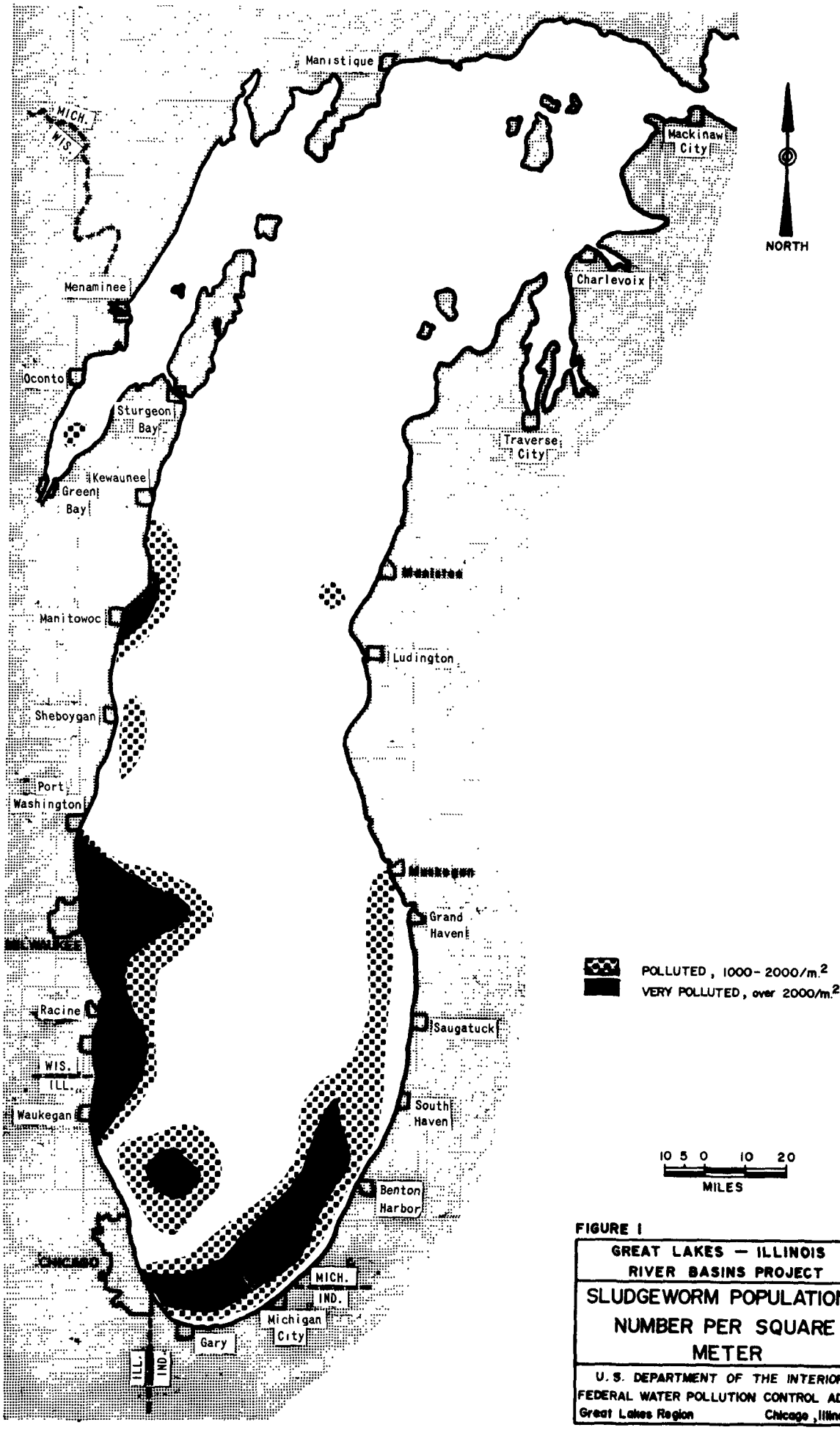

FIGURE 1

GREAT LAKES — ILLINOIS RIVER BASINS PROJECT
SLUDGEWORM POPULATION NUMBER PER SQUARE METER
U.S. DEPARTMENT OF THE INTERIOR FEDERAL WATER POLLUTION CONTROL ADMIN. Great Lakes Region Chicago, Illinois

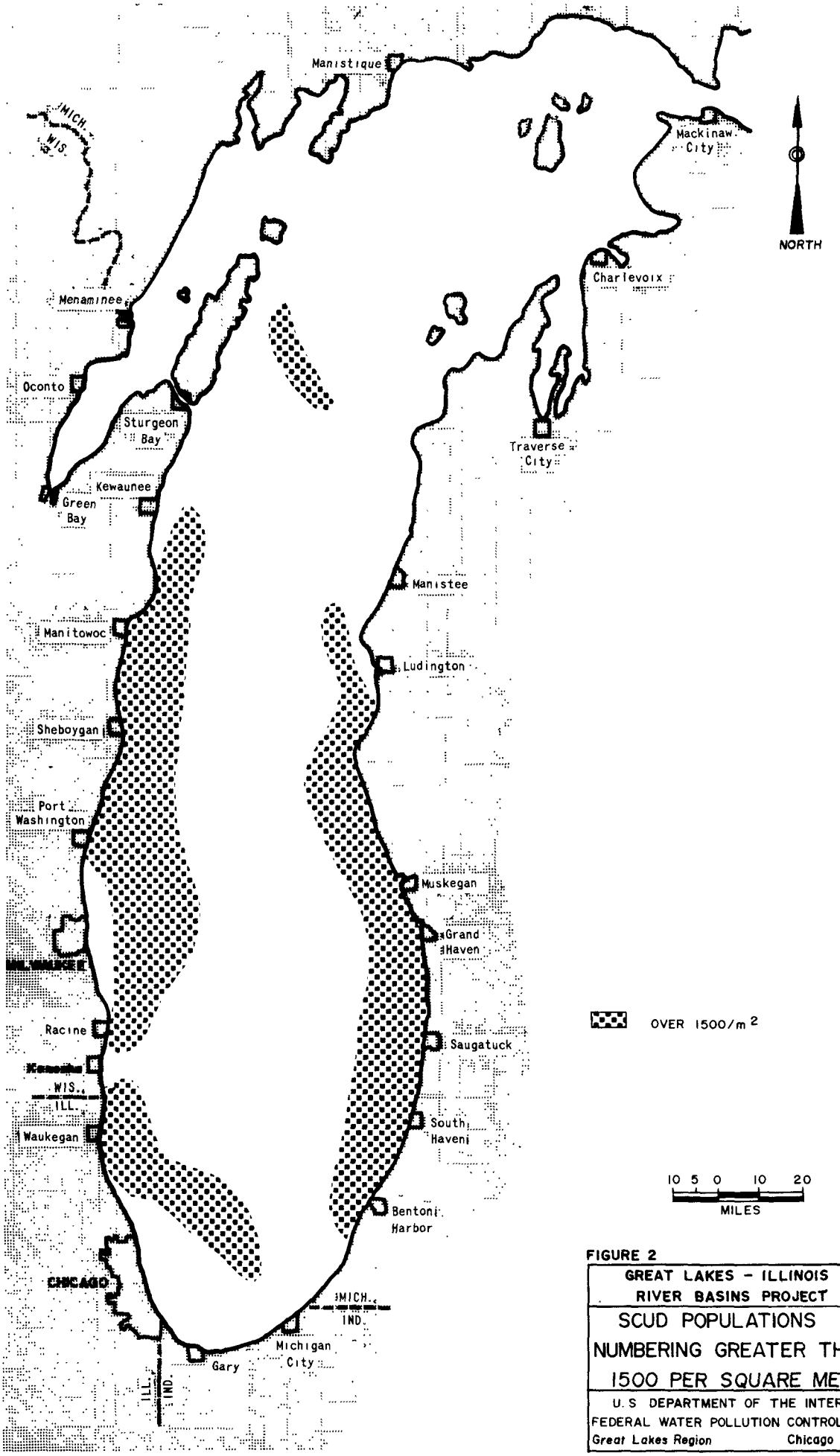

FIGURE 2

GREAT LAKES - ILLINOIS RIVER BASINS PROJECT
SCUD POPULATIONS NUMBERING GREATER THAN 1500 PER SQUARE METER
U.S DEPARTMENT OF THE INTERIOR FEDERAL WATER POLLUTION CONTROL ADMIN Great Lakes Region Chicago, Illinois

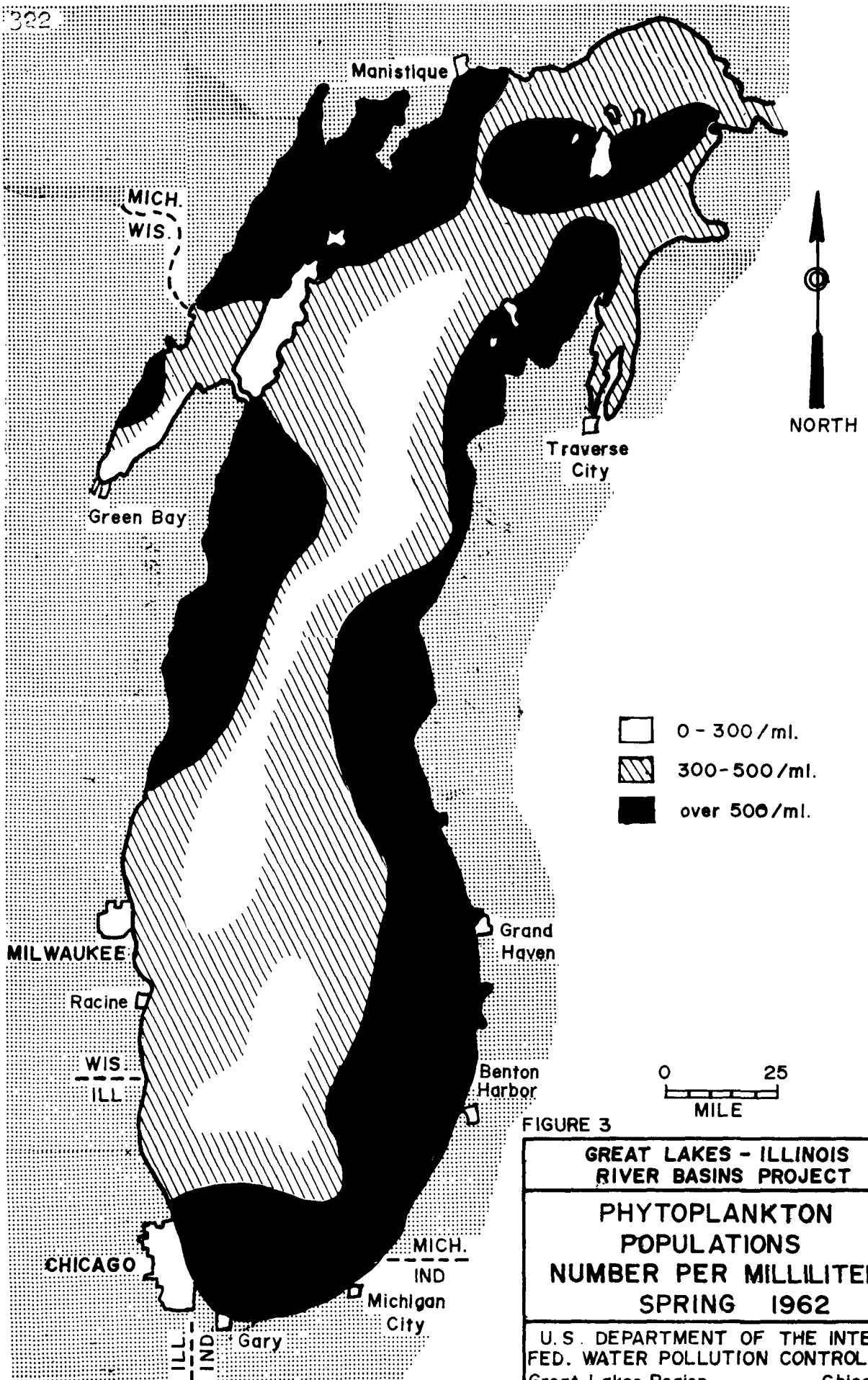

FIGURE 3

GREAT LAKES - ILLINOIS RIVER BASINS PROJECT

PHYTOPLANKTON POPULATIONS NUMBER PER MILLILITER SPRING 1962

U. S. DEPARTMENT OF THE INTERIOR
FED. WATER POLLUTION CONTROL ADMIN.
Great Lakes Region Chicago, Ill.

INSHORE AREA RESULTS

Massive areas along the perimeter of the southern half of Lake Michigan are polluted to such an extent that large populations of pollution-tolerant sludgeworms occur. The 2,100 square mile area classified as polluted in Figure 2, extending from Chicago northeastward around the southern tip of Lake Michigan, results from organic nutrients discharged by the large metropolitan areas bordering the lake. Lake sediments supporting populations of sludgeworms greater than 100 per square foot (approximately 1,000 per square meter) are considered polluted. Other areas that have polluted lake bed sediments occur in Green Bay, adjacent to the shorelines of Manitowoc, Sheboygan, Port Washington to Waukegan, and between Ludington and Manistee. Despite generally higher sludgeworm densities in inshore areas, the average number of organisms was depressed in a narrow band along the Chicago and Indiana shoreline. This was probably a result of wave action in the inshore areas which did not allow the settling of fine organic particles.

SPECIFIC AREAS - BOTTOM ANIMALS

Inshore areas receiving municipal wastes supported increased populations of pollution-tolerant bottom animals such as sludgeworms. The principal bottom material found at the southern tip of Green Bay was organic sediment, a favorable habitat for sludgeworms and bloodworms which were the predominant organisms. Total populations of bottom-dwelling organisms in 1962 and 1963 averaged 1,980 organisms per square meter near the mouth of the Fox River and gradually decreased to 500 or less ten miles out into the bay (Table 3). Burrowing mayflies were not found. Some pollution-sensitive snails occurred about five miles from the mouth of Fox River.

Twenty-eight square miles of lower Green Bay are classed as polluted; large number of sludgeworms inhabit this area. The number of sludgeworms was greater than the number of scuds in this area; this indicates a pollution by organic wastes. The population of bottom organisms inhabiting the area influenced by the Fox River is affected adversely, altered in composition, and does not supply the fish food potential necessary for maximum water use.

The area of Green Bay affected by the Oconto River discharge was degraded, as indicated by the types of benthic animals; only a few pollution-sensitive organisms were found within two miles of the river mouth. Benthic populations in 1962 and 1963 were highest near the mouth of the Oconto River with populations of 1,020 organisms

per square meter. Five miles from the mouth, populations had decreased to about 500 benthic animals per square meter; bloodworms predominated. A few pollution-sensitive scuds existed less than two miles from the mouth. The discharge of rich organic wastes from the Oconto area contributes to the enrichment and degradation of Green Bay.

Polluted conditions were also indicated in the vicinity of the Menominee and Peshtigo Rivers. In 1962 and 1963 there were fewer benthic organisms in the vicinity of the Menominee and the Peshtigo River outlets than there were in southern Green Bay. A benthic population of 800 per square meter, which consisted mainly of pollution-tolerant bloodworms and sludgeworms, was found at the mouth of the Peshtigo. Twenty-five hundred organisms per square meter, mostly sludgeworms and bloodworms were found near the mouth of the Menominee. Rapid improvement in conditions, in a predominantly sandy bottom, was shown by 1,300 scuds per square meter occurring about three miles from the mouth of this river.

The sand and clay bottom deposits in the near vicinity of Manitowoc and Twin Rivers supported a population of bottom organisms predominated by scuds because organic materials do not settle in this wave-swept area. Populations of 5,000 to 10,000 benthic animals per square meter, mostly sludgeworms, were collected four miles east of the Manitowoc River, indicating severe pollution caused by the deposition

of organic matter. A 228 square mile area off shore from the town of Manitowoc is classified as polluted because the sediments supported more than 1,000 sludgeworms per square meter indicating an organic enrichment of the lake bed.

The Sheboygan River outlet area was found to be degraded one mile from shore. Samples showed more than fifty percent sludgeworms out of a total of 7,000 organisms per square meter. In an 88 square mile area, sludgeworms numbered more than 1,000 per square meter thus indicating polluted conditions. Improved conditions were indicated by a predominance of pollution-sensitive scuds five miles from shore.

Degraded biological conditions in the Milwaukee River outlet area in 1962 and 1963 were indicated by the population of bottom organisms. The harbor was almost devoid of pollution-sensitive organisms. Populations of sludgeworms as high as 150,000 per square meter were found within Milwaukee harbor and further pollution was indicated seven miles from the river outlet by a predominance of pollution-tolerant organisms.

Fifty-six percent of the midges collected in the area from Port Washington to Kenosha were of the pollution-tolerant group. The entire 1,350 square mile shore area from Port Washington to Waukegan is classified as polluted with 1,100 square miles of it being extremely polluted. The pollution-sensitive scud population is depres-

sed in the area off Milwaukee. The existing bottom-animal population indicates organic pollution and a decreased fish food supply.

The deposition of organic materials in shore areas from Port Washington past Chicago to Benton Harbor is influenced by currents that flow parallel to the shore and reverse with the wind direction. These currents deposit organic materials in a band around the southern end of Lake Michigan.

The Root River (Racine) area of Lake Michigan was biologically degraded. Pollution-tolerant forms were very abundant near the mouth of the river and predominated five miles out into the lake. A benthic population averaging 18,560 per square meter (up to 97,000 per square meter) was found near the mouth of Racine Harbor. Ninety-six percent of these organisms were pollution-tolerant sludgeworms.

An examination of bottom samples in the harbor areas along the southern shore indicated that waste discharges were and are such that they contribute to a bottom deposit inhibitory to the establishment of large populations of bottom animals. Some of these deposits appeared to contain significant quantities of oil, grease and allied petroleum waste. The degradation of bottom organisms in the southern end of Lake Michigan extended out as far as twenty miles. The total area degraded by organic wastes discharged from the Chicago-Calumet area is 2,100 square miles as indicated by the increased population

of sludgeworms. Offshore from the Calumet area streams, pollution-tolerant organisms averaged 2,700 to 4,300 per square meter and there were only a few pollution-sensitive organisms. The depression of the population of clean water associated scuds results from toxic wastes being discharged from the Calumet area (Figure 1). To the north, along the Chicago shoreline, pollution-tolerant organisms averaged about 10,000 per square meter and pollution-sensitive forms averaged 500 per square meter indicating severe pollution.

The inshore areas of Lake Michigan from Calumet Harbor to Burns Ditch were and are extensively degraded biologically in degrees ranging from severe near Indiana and Calumet Harbors to less severe near Burns Ditch. Evidence that wastes from the Calumet area are deposited in the lake was found in the bottom materials and the odors of dredgings from this area of Lake Michigan. Petroleum odors were often detected in bottom muds. Pollution-tolerant organisms, mostly sludgeworms and sphaeriid clams, predominated in the areas along the southern shore.

Continuing along the south shore of Lake Michigan in a counter-clockwise direction, the southern tip of Lake Michigan reflected the effects of pollution in the vicinity of Trail Creek and the Galien River (Michigan City-New Buffalo area). Many of the bottom samples collected in the vicinity of the Galien River and Trail Creek were predominantly sludgeworms with populations of 5,000 to 10,000 benthic

animals existing a few miles from shore. One sample collected two miles northeast of Trail Creek consisted of fine black sand and supported a population of over 26,000 organisms per square meter--90 percent of which were sludgeworms. Many of the samples collected about four miles from shore were devoid of pollution-sensitive organisms. These conditions represent sustained degradation of the waters in this area through the discharge of wastes via Trail Creek and the Galien River.

Sludgeworms predominated within the South Haven Harbor. The bottom habitat emitted a sewage odor. The discharge of organic materials from the communities of South Haven, Saugatuck, Grand Haven and Muskegon results in a band of organically enriched sediments five miles off shore. This organically degraded lake bed supports a sludgeworm population exceeding 1,000 per square meter and a midge population that numbered 61 per square meter and was made up of 74 percent pollution-tolerant forms.

Organic enrichment in the area immediately adjacent to the outlet of White Lake at Whitehall was evident during 1962 to 1963. Almost 1,000 midges per square meter, mostly pollution-tolerant Tendipes plumosus and riparius, were found at that station.

Water quality conditions appeared good near the Pentwater and Little Sable Point areas. The bottom community in the sandy area off the Pentwater River, consists of mostly midges, scuds and sphaeriid clams, from 1,000 to 7,000 per square meter.

Water quality also appeared good near Little Sable Point. The benthic community consisted of about 5,000 organisms per square meter with substantial numbers of clean water scud.

The benthic population around the mouth of the Pere Marquette River was composed of less than 500 pollution-tolerant sludgeworms and midges per square meter. Amphipods, from 3,000 to 6,000 per square meter, predominated in samples collected within a two mile radius. The Ludington Spoil Bank supported a small community that was mostly scuds, less than 500 per square meter. The degradation of the lake bottom was less severe out from the communities of Ludington and Manistee in that midge populations increased to 124 per m^2 and pollution-tolerant forms comprised 46 percent of the total number (Table 4). However, a 36 square mile area between the towns supported a population of pollution-tolerant sludgeworms exceeding 1,000 per m^2.

The bottom fauna of Manistee Lake consisted mostly of pollution-tolerant midges and sludgeworms in populations of 500 to 1,000 per square meter. Near the outlet of the lake, no organisms were found. Lake Manistee deposits emitted sewage and petroleum odors. In adjacent Lake Michigan, bottom animal populations were less than 100 per square meter, although midges still predominated. The bottom fauna (approximately 1,000 organisms per square meter) consisted of over 50 percent amphipods about two miles out from the mouth of Manistee Lake.

No appreciable effects were noted from the Betsie River or the City of Frankfort on the benthic fauna of adjacent areas of Lake Michigan. Populations consisting mostly of 100 to 3,000 amphipods per square meter inhabited the sandy bottom.

At the northern tip of Lake Michigan, degraded localized conditions appeared near Manistique. Samples collected near the Manistique River mouth indicated that benthic populations were less than 1,000 per square meter. Only 67 midges per square meter were dredged up near the harbor. The bottom was found to consist mainly of organic matter and had a foul odor as the result of paper mill wastes. One mile south of this area, 100 to 250 pollution-sensitive scuds per square meter were found.

SPECIFIC AREAS - ALGAE

For several years the Chicago Park District has reported that beaches became fouled with algae washed in from the lake. In 1961, the offending organism at Oak Street and Montrose beaches was found to be Dichotomosiphon, a green filamentous alga similar in appearance to Cladophora. In 1962 Cladophora was the principal alga but Oedogonium was also present. All of these organisms require a hard substratum, or attachment surface. The windrows of algae that completely lined the beaches became four-smelling after a few days exposure to the summer heat. Flies and other insects covered the decaying masses.

In July, 1963 large floating masses of Cladophora and Mougeotia were found in southern Green Bay near the western shore. The pollution-tolerant blue-green alga, Lyngbya, was found attached to rocks on the bottom of Calumet Harbor in May 1963.

Phytoplankton concentrations of more than 500 organisms per milliliter are considered excessive; they may give the water an objectionable appearance, induce tastes and odors in domestic water supplies, and increase the cost of water treatment. The City of Kenosha has found it necessary to install a very expensive microstraining system for adequate water treatment because of excessive algae in the raw water. Other cities that have experienced taste and odor problems in their water supplies include Michigan City, Gary-Hobart and Chicago.

Green Bay is an example of accelerated eutrophication induced by man-made wastes. Severe oxygen depletion often occurs. Soluble phosphate levels averaged 0.07 mg/l as PO_4 and ranged as high as 0.60 mg/l; the critical level for algal blooms is considered to be 0.03 mg/l as PO_4. Ammonia nitrogen averaged 0.17 mg/l while NO_3-N averaged only 0.08. The highest phytoplankton populations occurred near the mouth of the Fox River. In July 1963, total populations of 20,000 per milliliter were found. These numbers decreased to 5,000 to 10,000 about ten miles out into the bay. The kinds of phytoplankton in this area were mostly green flagellates, centric diatoms and green coccoids. Blue-green forms were also found in

large numbers, from 700 to 1,500 per milliliter. Light penetration in Green Bay was greatly reduced (Secchi disc readings were only 0.2 meters compared to 16 meters in the northern basin). Near the mouth of the Fox River, average inorganic nitrogen values were close to 0.5 milligrams per liter and average total soluble phosphates were 0.20 milligrams per liter, or nearly seven times greater than the critical level necessary for algal blooms.

The algal population near the Oconto River mouth in July 1963 averaged over 80,000 phytoplankters per milliliter and consisted mostly of green flagellates and green coccoids. These same types predominated in the adjacent lake area in nuisance numbers, from 1,000 to 20,000 per milliliter. The proportion of diatoms was higher in Green Bay than in the Oconto River. Numbers of algae were considerably less on the eastern shore of Green Bay, from 500 to 5,000 per milliliter.

In spring, 1962, phytoplankton populations in excess of 1,200 organisms per milliliter were collected from the Manitowoc-Sheboygan area (Figure 3). This condition resulted from high soluble phosphate levels, ranging from 0.04 to 0.07 mg/l.

Milwaukee Harbor was found to be severely polluted by organic enrichment. It is estimated that 9,300 pounds per day of total phosphate was discharged into Lake Michigan at the mouth of the Milwaukee River. Soluble phosphate concentrations averaged 0.44 mg/l (nearly 15 times the level of phosphates considered critical for the

stimulation of algal blooms) and ranged as high as 1.4 mg/l. Adjacent water offshore averaged 0.07 mg/l. Total inorganic nitrogen in Milwaukee Harbor averaged 1.25 mg/l and ranged as high as 2.94 mg/l. Adjacent areas offshore averaged 0.32 mg inorganic N/l and ranged as high as 2.2 mg/l total inorganic nitrogen. A Secchi disc was visible to less than one meter in the harbor.

High phytoplankton counts in the Milwaukee area indicated enrichment. In the fall of 1962 over 1,500 organisms per milliliter were collected from the harbor. Generally, populations decreased with distance from shore, from over 1,000 per milliliter to less than 100 per milliliter at mid-lake (Figure 4). Predominant genera were Cyclotella, Stephanodiscus, Tabellaria, and Asterionella.

In June of 1963, populations of almost the same size and kind existed both in the river mouth and harbor area, from 1,000 to 20,000 per milliliter. Centric diatoms were the predominant kinds of algae. In spring, 1963, phytoplankton numbered nearly 6,000 per milliliter at the mouth of the Milwaukee River.

These biological findings reflect the deteriorated water quality in the Milwaukee vicinity of Lake Michigan and represent the gross pollution resulting from the domestic and industrial wastes discharged in this area.

The Root River (Racine) area of Lake Michigan was severely polluted with organic enrichment. In 1962 and 1963 soluble phosphate (PO_4) averaged 0.07 mg/l and ranged as high as 0.10 mg/l. Phytoplankton

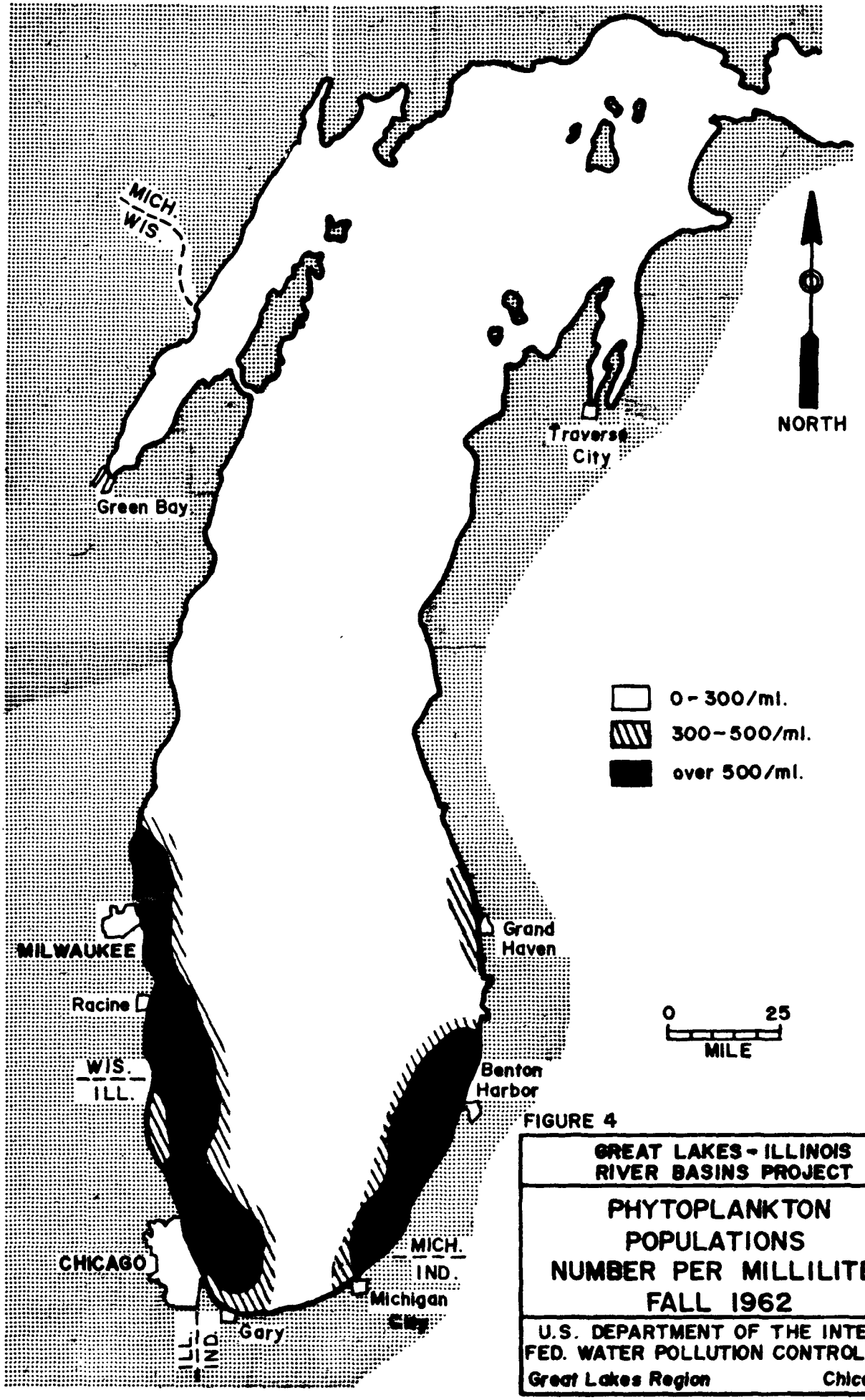

FIGURE 4

GREAT LAKES - ILLINOIS RIVER BASINS PROJECT

PHYTOPLANKTON POPULATIONS NUMBER PER MILLILITER FALL 1962

U.S. DEPARTMENT OF THE INTERIOR
FED. WATER POLLUTION CONTROL ADMIN.
Great Lakes Region — Chicago, Ill.

samples in the fall of 1962 contained 2,229 organisms per milliliter (Figure 4); this was one of the most dense phytoplankton populations encountered during the fall survey and may be compared with concentrations of less than 200 phytoplankton organisms per milliliter in the mid-lake deepwater areas. Cyclotella, Stephanodiscus, Tabellaria and Asterionella were the predominant algal forms. Melosira became the predominant form in the summer.

The waters of Chicago Harbor, Calumet Harbor and Indiana Harbor each contained excessive amounts of algal-stimulating nutrients. In Chicago Harbor, soluble phosphates averaged 0.04 mg/l and ranged as high as 0.15 mg/l. In Calumet Harbor, soluble phosphates averaged 0.05 mg/l and ranged as high as 0.14 mg/l; total inorganic nitrogen averaged 0.35 mg N per liter and ranged as high as 1.02 mg/l. Indiana Harbor water contained an average of 0.05 mg/l soluble phosphorus and ranged as high as 0.12 mg/l. Total inorganic nitrogen averaged 1.56 mg/l and ranged as high as 3.14 mg/l. A concentration of 0.30 mg/l inorganic nitrogen is considered critical for stimulation of algal growth in the presence of adequate phosphorus.

Phytoplankton populations in the Chicago-Calumet area remained very dense during the period of study. In 1962, up to 1,298 organisms per milliliter of sample were found (Figure 3). In 1963, phytoplankton populations increased to 2,143 phytoplankton organisms per milliliter. Light penetration in the Indiana Harbor Canal was severely restricted; a Secchi disc was not visible at one meter.

The distribution of phytoplankton in Lake Michigan was generally influenced by wind-produced currents. In spring, 1962, over 500 phytoplankton per milliliter were collected from inshore waters, beginning at the Chicago-Calumet area and continuing north up the entire eastern lake shore (Figure 3). By the summer of 1962, the current pattern had changed; phytoplankton distribution became more random, except for high numbers of organisms (over 300 per ml) near Chicago and South Haven (Figure 5). Fall, 1962, phytoplankton counts again revealed high concentrations of over 500 organisms per milliliter along both the southeastern and southwestern shores (Figure 4).

The effects of heavy pollutional loads were evident in the vicinity of the St. Joseph River and Benton Harbor. Soluble phosphate concentrations in the St. Joseph River averaged 0.24 mg/l and ranged as high as 0.94 mg/l. Total inorganic nitrogen concentrations averaged 1.12 mg/l and ranged as high as 3.04 mg/l. In spring, 1962, phytoplankton populations of 3,100 organisms per milliliter were concentrated in the waters just offshore from Benton Harbor (Figure 3). Mid-lake waters contained less than 200 phytoplankton organisms per milliliter in spring, 1962.

Lake Michigan waters in the vicinity of Grand Haven, Mighican consistently exhibited the effects of pollutional nutrient loadings. The Grand River, which enters the lake at this point, carries total soluble phosphate concentrations averaging 0.52 mg/l and ranging as high as 1.1 mg/l. Total inorganic nitrogen in Grand River water

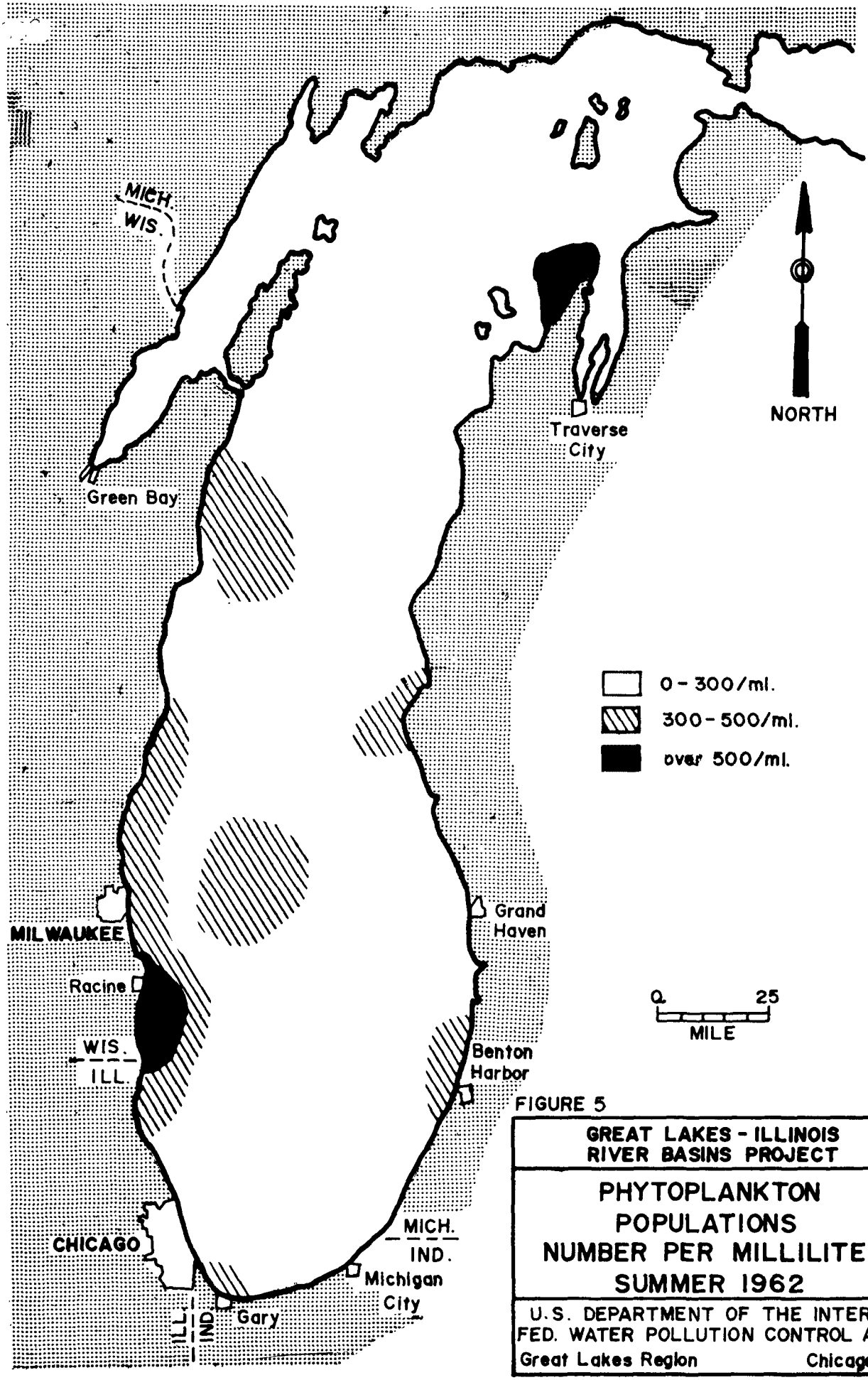

FIGURE 5

GREAT LAKES - ILLINOIS RIVER BASINS PROJECT

PHYTOPLANKTON POPULATIONS NUMBER PER MILLILITER SUMMER 1962

U.S. DEPARTMENT OF THE INTERIOR
FED. WATER POLLUTION CONTROL ADMIN.
Great Lakes Region Chicago, Ill

GPO 806-408-4

averaged 1.4 mg (N)/l and ranged as high as 3.9 mg/l. Phytoplankton populations in adjacent Lake Michigan waters were correspondingly high. Phytoplankton counts averaged 2,230 organisms per milliliter in summer, 1962 (Figure 3). A high concentration of 630 phytoplankton organisms was again found in the Grand Haven area in fall, 1962 (Figure 4).

The Manistique River at the northern tip of Lake Michigan, carried heavy concentrations of algal-stimulating nutrients. Soluble phosphate concentrations in this river averaged 0.04 mg/l and ranged as high as 0.09 mg/l. Total inorganic nitrogen concentrations averaged 0.47 mg/l and ranged as high as 2.46 mg/l. Phytoplankton populations in Lake Michigan offshore from Manistique consisted of 528 organisms per milliliter in spring, 1962. Mid-lake waters in northern Lake Michigan contained less than 300 organisms per milliliter (Figure 3).

APPENDIX

METHODS

BOTTOM ANIMALS

Sampling of bottom organisms was accomplished with three Petersen dredge hauls at each lake station. These were washed through U. S. Standard No. 30 mesh bronze seine cloth and the remaining organisms and debris preserved with formalin for further analysis in the laboratory.

PHYTOPLANKTON

Samples for phytoplankton identification were collected with polyvinylchloride (PVC) sampling bottles attached to a cable at intervals of zero, 5, 15, 30, 50, 75 and 100 meters from the surface, and at surface, mid-depth and near bottom where depths were less than ten meters. Sufficient formalin was added to each phytoplankton sample to effect a 3 percent solution. One milliliter of the water sample was placed in a Sedgwick-Rafter counting cell and examined microscopically at 200 X.

LIGHT PENETRATION

Light penetration was determined with a standard, 20 centimeter diameter Secchi disc. The limit of visibility was defined as the mid-point between the depths of disappearance upon lowering and reappearance with the disc was again raised. Measurements were reported in meters.

TABLE 1

DISTRIBUTION OF BOTTOM ORGANISMS BY DEPTHS
LAKE MICHIGAN, 1962-64

Depth in Meters	Number per Square Meter
0-9	7494
10-19	3357
20-29	4694
30-39	5752
49-49	3020
50-59	2713
60-69	2146
70-79	1505
80-89	889
90-99	642
100-109	647
110-119	721
120-129	264
130-139	425
140-149	506
150-159	186
160-169	201
170-179	70
220-229	140
230-239	88
260-269	5019

TABLE 2

LAKE MICHIGAN PHYTOPLANKTON
MOST COMMONLY ENCOUNTERED GENERA

Anabaena
Anacystis
Ankistrodesmus
Asterionella
Chlorella
Chodatella
Closteriopsis
Cocconeis
Cyclotella
Dinobryon
Euglena
Fragilaria
Golenkenia
Gomphosphaeria
Gonium
Melosira
Navicula
Nitzschia
Oocystis
Phormidium
Rhizosolenia
Scenedesmus
Schroederia
Selenastrum
Stephanodiscus
Synedra
Tabellaria
Unidentified Green Coccoids
Unidentified Green Flagellates

NOTE: Only those genera whose average total per milliliter exceeds 10 percent of the average grand total are considered predominant.

TABLE 3

BIOLOGICAL DATA - LAKE MICHIGAN, 1962-1964

	BOTTOM ORGANISMS Numbers per square meter				PHYTOPLANKTON Numbers per milliliter				
Quad. 1	Scuds	Sludge-worms	Midges	Total*	Spring 1962	Summer 1962	Fall 1962	Spring 1963	Summer 1963
F-19	1,450	780	100	2,650		176			
E-19	470	1,310	20	2,000		171	246	1,155	1,106
D-19	50	1,950	20	2,210		301	398	1,311	1,035
C-19	80	4,630	20	6,000		1,036		1,588	1,036
G-18	1,190	1,670	100	3,160			694		
F-18	720	4,750	130	6,200		248	175	1,870	
E-18	2,710	1,730	140	5,160	748		172		
D-18	610	240	20	920	1,298	258	350	2,143	
C-18	180	490	70	1,670		233	588	1,347	
H-17	3,180	1,660	140	5,540			1,022		
G-17	1,940	4,620	120	7,030	3,108	224	261		
F-17	310	100	0	410	322		66		
E-17	1,120	470	x	1,600		66	119		
D-17	3,840	2,180	30	6,090	420	66	239		
C-17	1,610	1,850	50	3,910		225	546	357	
B-17	1,240	400	260	1,910					
H-16	4,020	1,040	30	5,490		357	853		
G-16	1,170	1,760	10	3,400	900	98	148		
F-16	220	170	0	410			154		

*Includes miscellaneous organisms not mentioned in Table

1. See Figure 6 for locations of quadrangles.

	BOTTOM ORGANISMS Numbers per square meter				PHYTOPLANKTON Numbers per milliliter				
Quad.	Scuds	Sludge-worms	Midges	Total*	Spring 1962	Summer 1962	Fall 1962	Spring 1963	Summer 1963
E-16	130	190	x	330		165	132		
D-16	190	40	x	240	253	28	143		
C-16	2,260	1,590	80	4,810		402	1,035	572	
B-16	3,220	5,420	180	10,270		384	371	638	
I-15	1,700	380	30	2,300			154		
H-15	4,360	1,130	40	5,860	1,503	294	203		
G-15	340	180	10	540	638	70	110	416	
E-15	80	60	0	140	182				
D-15	150	70	x	220	364	198			
C-15	1,160	2,400	120	3,730		694	2,229	2,552	
B-15	1,200	15,910	210	18,560		896	1,867		
I-14	3,060	300	40	3,660			443		
H-14	2,280	1,240	0	3,580			108		
G-14	390	10	10	410				836	
C-14	5,820	1,370	50	7,340		270	145		
B-14	10	13,980	820	16,360		423	1,530		
H-13	3,970	1,140	20	5,530	2,230	134	295		
G-13	810	530	20	1,400	474	121	196	660	
E-13	1,200	520	20	1,800	378				
D-13	1,560	1,620	100	3,330	210	385			
C-13						242	121		
B-13	500	15,770	90	16,980		484	1,770	6,310	
H-12	4,550	860	290	5,860			270		

*Includes miscellaneous organisms not mentioned in Table.

GPO 806-408-3

	BOTTOM ORGANISMS Numbers per square meter				PHYTOPLANKTON Numbers per milliliter				
Quad.	Scuds	Sludge-worms	Midges	Total*	Spring 1962	Summer 1962	Fall 1962	Spring 1963	Summer 1963
B-12	1,810	610	30	2,660				1,107	
H-11	4,180	80	140	4,880					924
G-11	3,770	980	80	5,180	1,664	354			1,452
F-11	300	90	10	400		252		1,474	
E-11	1,070	760	0	1,850		121			
D-11	170	60	x	230	264	154			
C-11	5,010	1,470	50	7,140	896	322		1,267	
B-11	5,150	320	40	6,590				1,232	
H-10	1,150	140	170	1,630					
G-10	1,440	70	60	1,720					
F-10	60	10	0	90					
C-10	3,770	690	20	4,580					
H-9	310	120	60	520					
G-9	1,760	1,130	110	3,090	616			1,689	
E-9	140	90	10	240	168	308			512
D-9	1,740	750	40	2,590		319		1,035	
C-9	3,020	2,890	80	6,140	3,696	220		5,940	
H-8	80	20	80	230	373			1,078	
G-8	30	90	10	130	189				
E-8	30	10	0	40	770				

*Includes miscellaneous organisms not mentioned in Table.

	BOTTOM ORGANISMS Numbers per square meter				PHYTOPLANKTON Numbers per milliliter				
Quad.	Scuds	Sludge-worms	Midges	Total	Spring 1962	Summer 1962	Fall 1962	Spring 1963	Summer 1963
D-8	2,990	650	10	3,840					
C-8	x	0	0	x					
I-7	400	100	390	920					462
H-7	630	120	30	790	463				352
G-7	1,120	540	160	1,900	165				
D-7	20	140	30	210	1,254				
C-7	0	80	210	290					2,728
B-7	10	1,620	280	1,980	209				16,209
A-7	0	300	0	300					60,088
L-6	60	10	0	70					
K-6	110	20	40	190					
I-6	950	1,240	20	2,250	858				
E-6	240	110	x	370	308				
D-6	950	920	80	1,960					2,882
C-6	0	90	110	240					2,100
B-6	10	190	780	1,020	468				5,375
L-5	440	60	10	520					
K-5	470	110	20	620	1,067	1,067			
G-5	20	30	0	60					
F-5	2,060	10	10	2,280					
D-5	20	130	10	200	484				
C-5	200	720	170	1,220	440			6,160	2,018

*Includes miscellaneous organisms not mentioned in Table.

	BOTTOM ORGANISMS Numbers per square meter				PHYTOPLANKTON Numbers per milliliter				
Quad.	Scuds	Sludge-worms	Midges	Total	Spring 1962	Summer 1962	Fall 1962	Spring 1963	Summer 1963
N-4	10	10	0	20					
M-4	140	60	30	260					
L-4	760	470	210	1,510	407			1,056	
K-4	1,420	180	20	1,660	660				
J-4	500	320	30	860	319			396	
F-4	440	100	10	610	693				
L-3	1,060	730	10	1,810	253			896	
I-3	690	480	30	1,240	231				
H-3	10	50	10	80	792			3,124	
E-3	370	380	50	1,150	968			968	
N-2	20	70	180	290	308				
M-2	20	310	40	410					
K-2	30	100	60	420	330				
I-2	600	210	70	890	528			1,008	

*Includes miscellaneous organisms not mentioned in Table.

TABLE 4

MIDGE LARVAE DATA WITHIN TEN MILE LIMIT FROM SHORE

Area	Total No. Per M^2	Percent of Total			
		Pollution Tolerant	Cosmo-politan	Clean Water	Other
Lower Green Bay	201	80	16	0	4
Kenaunee-Sheboygan	53	0	29	22	49
Fort Washington-Kenosha	118	56	19	3	22
Waukegan-Evanston	113	24	57	0	19
Chicago-Gary	39	6	79	0	14
Michigan City to Buffalo	92	37	59	0	4
Benton Harbor-South Haven	121	51	34	0	5
Saugatuck-Muskegon	61	74	7	7	12
Ludington-Manistee	124	46	16	10	28
Arcadia-Mackinaw City	61	21	56	13	10
Kewaunee-St. Ignace	12	0	23	37	40

DR. A. F. BARTSCH

DR. BARTSCH: The report is based on field investigations carried out by this agency.

The facts revealed by all of these studies collectively make up the story of what has been happening to Lake Michigan in recent times. Many aspects of the story are far from clear, but from study of these reports one can derive an insight as to what seems to be happening to the lake. One gets the impression that the results of all of these investigations are substantially in agreement, that all pertinent interpretations of the findings support essentially similar conclusions as to the present status of Lake Michigan so far as eutrophication is concerned.

As we note from statements that were made here yesterday, the problem of eutrophication is one of the chief concerns about Lake Michigan. In simplest terms, eutrophication means the aging process of the lake in which its waters become more fertile and acquire a greater capability to grow algae and other forms of unwanted living matter. Frequently, the algae become so numerous that they make the water green

and interfere in many ways with the continued usefulness of the water. This is one of the most common, objectionable symptoms of eutrophication. In addition, there are other more subtle symptoms of change that sometimes would pass without being noted except by the scientist investigator. Nevertheless, such subtle changes are clues that slow-acting, long-range changes are taking place.

Changes to look for include: decrease in transparency of the water; increase in total dissolved solids, including especially nitrogen and phosphorus needed for growth of substantial quantities of algae; loss of dissolved oxygen in the deeper layers; and changes in bottom-dwelling animals and microscopic plants. When eutrophication has not proceeded to an obvious and objectionable stage, it becomes necessary to examine the combination of these more subtle clues in order to sense the existing state of affairs. In many cases, such scrutiny may reveal a forecast of things to come. Some changes such as these are now appearing in Lake Michigan.

DR. A. F. BARTSCH

Many scientists have been studying various aspects of the "personality" of Lake Michigan and have produced tremendous quantities of valuable information. I call attention especially to the efforts of Dr. Alfred M. Beeton of the University of Wisconsin in Milwaukee. He was the first, I believe, to perceive, assess, and describe clearly the responses of the Great Lakes, including Lake Michigan, to the eutrophying influences of human affairs in the watershed area. I would like to propose that the three of his papers that call attention to this matter be accepted as exhibits for the record of this conference:

Beeton, A.M. 1965. "Eutrophication of the St. Lawrence Great Lakes." Limnol. & Oceang. 10:240-254

Beeton, A.M. 1966. "Indices of Great Lakes Eutrophication." Publ. No. 15, Great Lakes Research Div., The University of Michigan, p. 1-8.

Beeton, A.M. 1967. "Changes in the

Environment and Biota of the Great Lakes." Presented at the International Symposium on Eutrophication, June 11-16, 1967, Madison, Wisconsin.

It is in press at the moment.

MR. STEIN: Without objection, they will be considered as exhibits. I think these papers are published and generally available.

(Copies of Exhibit 2, the document entitled "Eutrophication of the St. Lawrence Great Lakes," by Dr. A.M. Beeton, are on file at the Federal Water Pollution Control Administration Office in Washington, D. C., and at the Regional Office in Chicago, Illinois.)

(Copies of Exhibit 3, the document entitled "Indices of Great Lakes Eutrophication," by Dr. A. M. Beeton, are on file at the Federal Water Pollution Control Administration Office in Washington, D. C., and at the Regional Office in Chicago, Illinois.)

(Copies of Exhibit 4, the document entitled "Changes in the Environment and Biota of the Great Lakes," by Dr. A. M. Beeton, are on file at the Federal Water Pollution Control

DR. A. F. BARTSCH

Administration Office in Washington, D. C., and at the Regional Office in Chicago, Illinois.)

DR.BARTSCH: One of the principal factors that affect the rate of eutrophication is the extent to which nutrients needed by algae enter the body of water. Under natural conditions, unaffected by the affairs of man, the input of nutrients in runoff from the watershed land and in precipitation generally is low. Then the aging process usually proceeds at a slow rate. Cultural developments on the watershed, such as the establishment of cities and cultivation or other disturbance of the land, accelerate nutrient input. The result of this input is shown clearly in a chart prepared some years ago by Dr. A. D. Hasler of the University of Wisconsin. (Fig. 1.)

(Which said chart is as follows:)

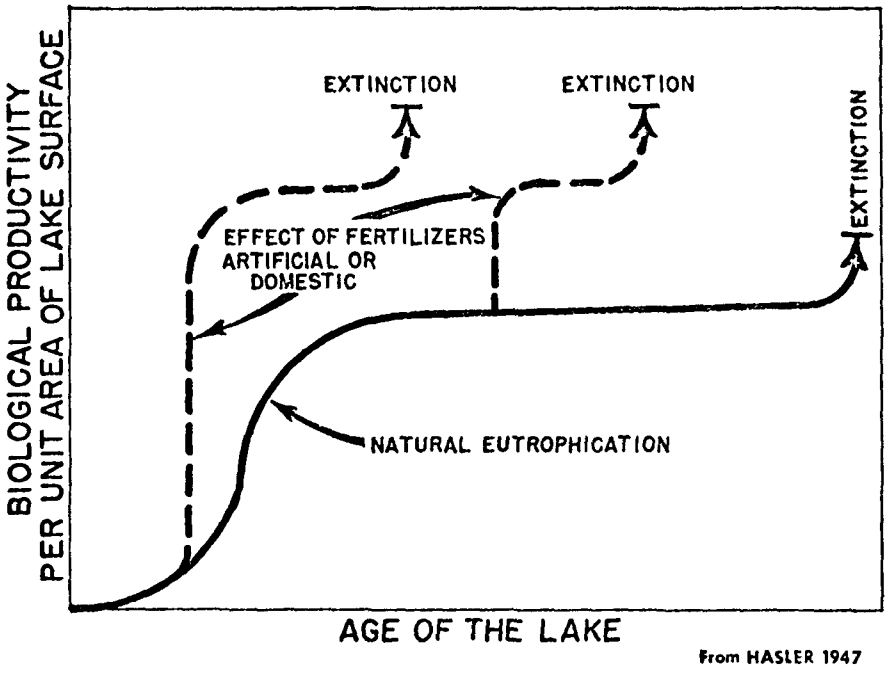
BIOLOGICAL PRODUCTIVITY
PER UNIT AREA OF LAKE SURFACE
EXTINCTION
EXTINCTION
EXTINCTION
EFFECT OF FERTILIZERS
ARTIFICIAL OR
DOMESTIC
NATURAL EUTROPHICATION
AGE OF THE LAKE
From HASLER 1947

FIGURE NO. 1

DR. A. F. BARTSCH

The influences of cultural development--you will find them noted here as the addition of fertilizer--are superimposed on the natural aging process and accelerate it so that the terminal point is reached much more quickly. It makes no difference where along the time scale the human influence is brought to bear. The end result is always the same. The lake is brought more rapidly to a higher level of fertility and greater crops of algae and other plants are produced than under natural influences alone.

The outcome of increasing nutrient input is not merely a theory. It is a historical fact repeated over and over again in every continent. This can be verified readily by reference to the well known histories of the lakes at Madison, Wisconsin; Lake Washington, at Seattle; and in Europe--at Lake Geneva, Lake Zurich, and the Bodensee, to mention only a few.

Until recently, most studies of eutrophication have been with fairly small lakes. Because of its size, one can expect

that Lake Michigan will differ in the details of its response to the forces of eutrophication. But there is no doubt that even here these forces will be felt and produce undesirable change. The unfortunate end result is inevitable if preventive measures are not taken in time.

Algal nutrients of special concern are nitrogen and phosphorus. Studies by the Federal Water Pollution Control Administration have shown that soils of the Lake Michigan Basin yield phosphate to the runoff water at a rate of from 31 to 250 pounds per square mile per year. It is estimated that the annual input of phosphate to the lake from these sources is about 5 million pounds. This is about one-third of the total input; the remaining two-thirds comes from municipal and industrial wastes.

Comparable figures for nitrogen are not available, but it is known that rivers tributary to the lake bring in 69 million pounds annually. This is about 42 percent of the total input. The remainder comes from direct discharges and precipitation.

DR. A. F. BARTSCH

Nitrogen and phosphorus are normal components of sewage. They are present in amounts of about 8 to 12 pounds of nitrogen and 1.5 to 4 pounds or more of phosphorus per person per year. Even after conventional secondary treatment substantial amounts of these nutrients still remain to be discharged into surface waters. Sewage contains other components, also, both organic and inorganic, which have stimulatory influences on the growth of algae. However, most concern has focused on inputs of phosphorus for the following reasons.

First, algae can obtain phosphorus from the water when it is present in exceedingly minute amounts. In many lakes exhaustion of the phosphorus supply by algal growth seems to serve as a deterrent to further growth. Second, although nitrogen also is a vital nutrient for algal production, there are various largely uncontrollable opportunities for nitrogen input--for example, fixation of nitrogen gas from the atmosphere by some species of algae and fall in, if you will, from the atmosphere. And third, phosphorus input is more amenable to control.

In any event, the quantity of algae a lake can grow is largely determined by the amount of nutrients available. The more nutrients there are, the more algae there will be, the greater the nuisance will become. There is evidence that continued input of nutrients can finally bring a lake beyond the point of no return--to the stage where continuous recycling of nutrients already present can result in production of nuisance growths of algae.

The tremendous mass of data gathered on the physical, chemical, and biological status of Lake Michigan indicates that the lake, as a whole, is beginning to show some early symptoms of accelerated eutrophication. In this respect the offshore areas differ from the inshore areas in the nature and extent of their responses to the input of nutrient-bearing pollutants. Consequently, it is necessary to examine them separately.

Offshore Areas

The offshore, deep water areas of Lake Michigan do not now show substantial effects of

pollution or the onset of eutrophication forces. They do, however, exhibit a combination of minor and subtle changes that suggest that the real beginnings of eutrophication are just around the corner. This view is supported by a number of factors that I wish to point out.

The standing crop of algae, as shown by periodic sampling during 1962 and 1963, has a low population density, between 100 and 300 organisms per milliliter. It is partly because of this low algal population that the water has a high transparency--in 1966 averaging 6 meters, as shown by a common measuring device called a secchi disc. This is less transparent than Lakes Superior and Huron but more transparent than Lakes Erie and Ontario. Unfortunately, there is no historical record of transparency to show if and to what extent water clarity is changing. One study of primary productivity--roughly the rate of algal growth--showed a rate in 1964 only slightly higher than in Lake Superior. We might consider this to be a favorable observation.

Two changes in species composition in

the zooplankton have been noted. A water flea, Bosmia longirostris, has replaced another, Bosmia coregoni, and while it may seem frivolous to some of you for me to stand here and talk about water fleas, I assure you that this is significant because a similar change occurred in Lake Zurich in Switzerland concurrent with and as evidence of eutrophication changes which were occurring there. There, also, pollution is the prime source of nutrient input. Another small organism , called Diaptomus oregonensis, has appeared and become prominent since 1927. What this means beyond the fact that change is occurring is not now clear.

The three principal kinds of bottom-dwelling animals that occur in offshore areas are the same now as observed in 1931 and 1932. These same organisms commonly are found in other lakes that are not eutrophic. But recent studies by the Great Lakes Research Division of the University of Michigan have shown that these animal populations have now increased markedly in density. This is a response, most likely, to enrichment of the bottom sediments,

another sign of movement toward eutrophication.

Except in the south end of the lake, where chemical quality of the water is declining, offshore water presently is of high quality. Nevertheless, indications of gradual chemical buildup are apparent. Total inorganic nitrogen concentration averages 0.19 milligrams per liter, and total phosphate is in the neighborhood of 0.02 milligrams per liter. Concentrations of these two nutrients in the offshore waters have not yet reached levels that frequently cause nuisance growths of algae. In his studies, Dr. Beeton has noted that total dissolved solids have increased 30 parts per million in 90 years, sulfate 13 parts per million, and chloride about 6 parts per million. These increases are not great. But, if no preventive action is taken, chemical buildup will increase so that nutrients and other dissolved solids will move to levels characteristic of eutrophication.

Some data on dissolved oxygen concentrations in deep waters of the lake are available for 1954, 1955, 1960, 1961 and 1966. It has been pointed out that in the decade since the mid-'50s

the oxygen content has decreased slightly. In 1954-55 the oxygen values equaled or exceeded 90 percent of saturation in 35 percent of the cases; in 1966, 90 percent of saturation was exceeded in only 10 percent of the cases. If such decreasing oxygen is more than a momentary variation, and it appears to be, it should be viewed with concern as a symptom of movement toward eutrophication.

Inshore Areas

In contrast to the offshore waters, the inshore areas have changed drastically and in many ways under the influence of human activities. In recent years both attached and free-floating algae, Cladophora and others, frequently have appeared in nuisance proportions at various harbor and waterfront areas around the lake. I am sure from the many references made to Cladophora yesterday that there are many of you here who have had some firsthand experience with this kind of problem.

These attached growths periodically break loose by wave action and wash ashore to

litter the beaches in slimy windrows. Resulting nuisances have occurred repeatedly at such points as Chicago, Green Bay, Milwaukee, Manitowoc, Sheboygan, Racine, Calumet Harbor, Indiana Harbor, Benton Harbor, Grand Haven, and other localities.

I have a slide now which shows that in the summer of 1967 algal growths of this kind were more onerous than previously.

(Which said map follows:)

AREAS WHERE CLADOPHORA FOULED BEACHES

1967

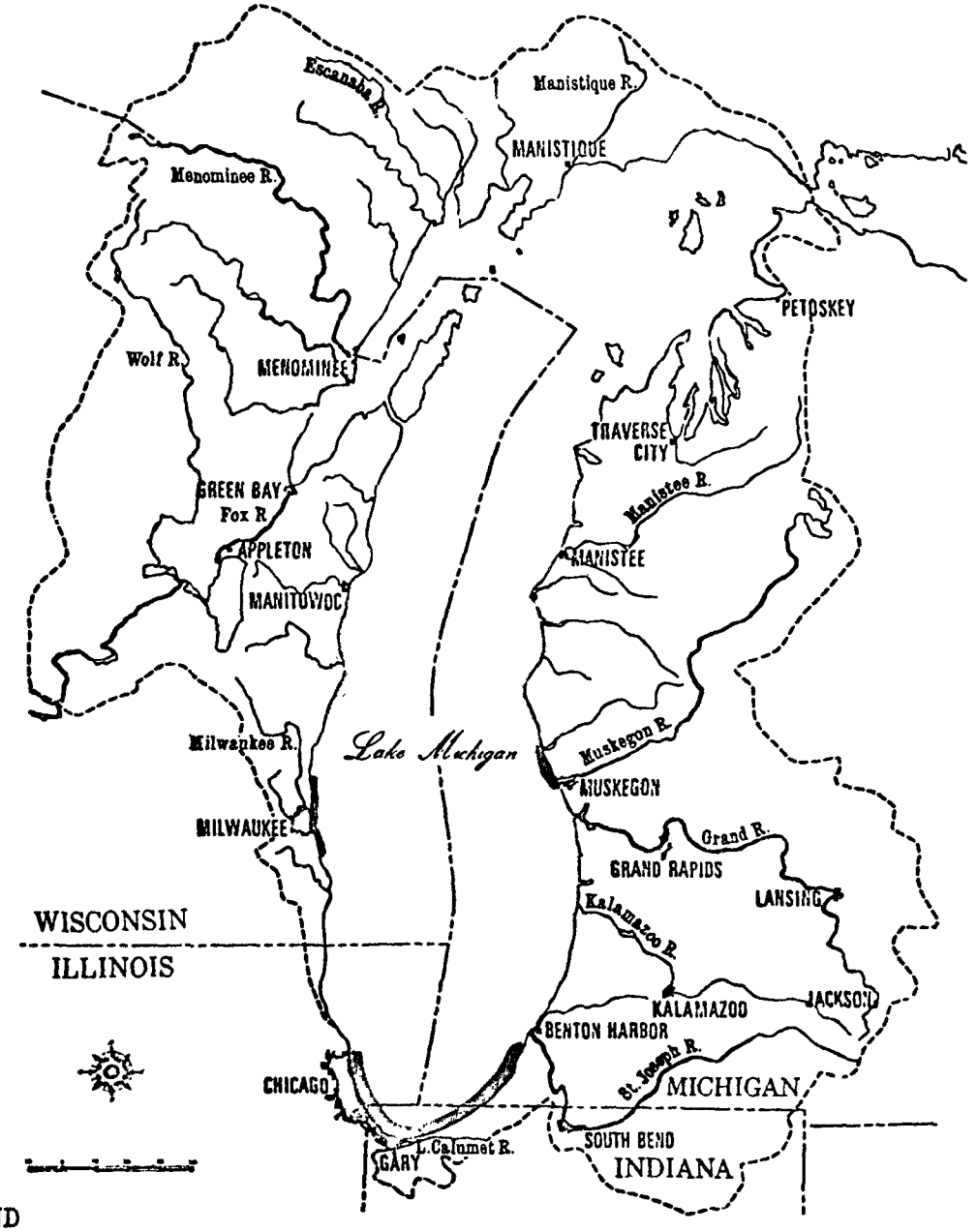

FIGURE NO. 2

They also appeared in new places and more luxuriantly than had been the case before. The dark red, as the legend of this map should indicate, are the areas where these growths were especially onerous during 1967. I am not sure that you can see it, but along the east shore there is a pink margin which indicates that now this entire east shore of the lake practically is involved with it. The growth of such masses of algae is a direct response to concentrated high levels of nutrients brought into the lake by way of municipal sewage, land runoff, urban drainage, industrial wastes, and other sources. In Lake Erie, luxuriant growths of Cladophora seem to have been a forerunner of the more widely dispersed free-floating or planktonic growths of algae that now exist there.

Overabundant planktonic or free-floating algae also have caused problems. Among such problems are shortened filter runs and other difficulties in water treatment plants at Green Bay, Sheboygan, Milwaukee, Waukegan, Evanston, Chicago, Gary, Michigan City, Benton Harbor, Holland, Grand Rapids, and Muskegon. Taste and

odors in water supplies caused by algae have occurred at Kenosha, Chicago, Evanston, and other North Shore cities.

In the southern end of the lake, there is ample evidence of deterioration of chemical water quality in areas adjacent to population centers. Total inorganic nitrogen and soluble phosphate were found to be highest here. Along with Green Bay, these also are the areas of greatest algal growths, sometimes reaching the point that water transparency diminished to less than one meter.

At Green Bay, high nutrient input brought soluble phosphate to an average concentration of 0.07 milligrams per liter, sometimes reaching as high as 0.6 milligrams per liter. In Milwaukee Harbor, soluble phosphate averaged 0.44 milligrams per liter--15 times the concentration considered critical for the production of nuisance growths of algae--and sometimes reached as high as 1.4 milligrams per liter. Many other examples of high nutrient availability could be cited, but these are indicative of nutrient conditions existing in many of the

inshore trouble spots.

According to long-term records available at Chicago, plankton algae increased at an annual rate of 13 new organisms per milliliter between 1926 and 1958. They also reached three times the numbers found in offshore waters. Such conditions of accelerated eutrophication exist and usually extend lakeward in some form or other at many points around the lake, such as at Milwaukee, Racine, Chicago Harbor, Calumet Harbor, Indiana Harbor, St. Joseph, Benton Harbor, and Grand Haven.

In many of these areas, further evidence of lake deterioration is seen in the nature and density of bottom animal populations. In general, over the years there has been a shift from a normal assemblage of animals characteristic of clean water to dense populations of one or two kinds, such as sludgeworms and bloodworms, commonly taken as evidence of organic pollution.

I have a slide here now that will show you some of this distribution, so along with the increased growth of algae many of these inshore areas which you see here on this map that

receive municipal and other wastes show this kind of biological response.

(Which said map follows:)

SLUDGEWORM POPULATION
NUMBER PER SQUARE METER

VERY POLLUTED, OVER 2000/m^2 POLLUTED, 1000-2000/m^2

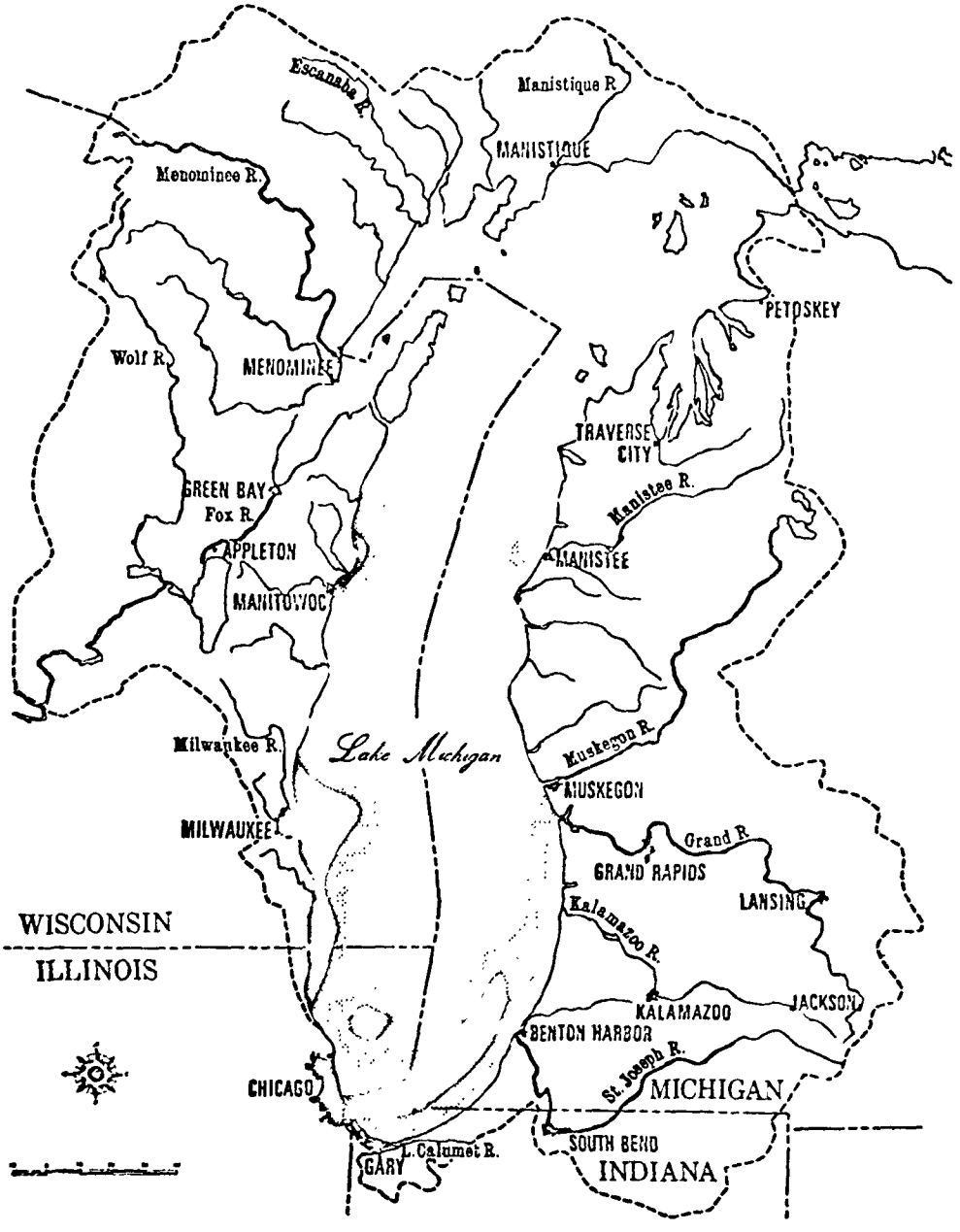

FIGURE NO. 3

We see here especially the density distribution of sludgeworms as they existed in 1962. Inshore areas of pollution in which the population of bottom animals are thus impaired total 3,475 square miles along the southern perimeter of the lake, almost uninterrupted from Port Washington to Muskegon. Although not shown in the figure, similar conditions also occur over some 28 square miles of lower Green Bay, as well as locally at Manitowoc, Sheboygan, South Haven, Benton Harbor, Saugatuck, Ludington, Manistee, and Manistique.

After these pronouncements, let's consider then what this seems to mean.

Considerations

While the deep water areas of Lake Michigan give only a suggestion of creeping eutrophication, the lake's response to increasing nutrients in the inshore waters is obvious and shows that the lake can respond when nutrients for plant growth are abundant. Lake Michigan, as a whole, is now at an early stage in the eutrophication process that was passed through

by Lake Erie at some point in the past. With increasing time, nutrient levels will increase until finally the entire lake becomes involved. With certain reservations, Lake Erie can be viewed as a prototype and a preview of what can happen in Lake Michigan if nutrient-bearing waste input continues unabated.

Using available data, one can examine existing nitrogen and phosphorus input-output balances for Lake Michigan (Table I.)

(Which said Table follows:)

Table I

Lake Michigan

Estimated Annual Input and Output
of Nitrogen and Phosphate

1963-64

	Input	Output	Retained in Lake
Nitrogen	166.1 million lbs.	32.2 million lbs.	81%
Phosphates	14.6 million lbs.	0.8 million lbs.	95%

DR. A. F. BARTSCH

In doing so--and I hope you can see this better than I can at the moment--you will find that there are two points that I wish to make. The first, the estimated inputs of nitrogen and phosphates are substantial. And if there are some of you who cannot read the numbers on this chart, you will note--I will read them for you--the input of nitrogen is 166, roughly, million pounds per year and the input of phosphate roughly 15,000,000 pounds per year. We will notice second that the output or the loss by outflow through the Straits of Mackinac are 32, roughly, million pounds of nitrogen per year and eight-tenths of a million pounds of phosphates per year. You will notice also, and this, I think, is very significant, we have occurring an estimated 81 percent retention of nitrogen in the lake and a 95 percent retention of phosphates in the lake.

While percentage retention may vary considerably among lakes and among different nutrient elements of concern, substantial retentions are not unusual. This, together with changes that have been permitted to occur

over the years in the inshore waters, the low flushing rate of Lake Michigan, the awareness of what has happened to Lake Erie and other lakes, and the emerging evidence of subtle chemical changes in water quality, emphasize the need for action now.

We have seen forecasts that population of the Lake Michigan Basin will soar from a 1960 level of 4.2 million to 12.1 million by the year 2020, that industrial wastes will increase by a factor of 3, that chlorides in the lake will build up from a 1965 level of 7 milligrams per liter to 12, and sulfates from 20 to 29 milligrams per liter. One can only expect that nutrients, such as nitrogen and phosphorus, although complicated by their biological involvement, will increase in somewhat the same pattern also. If these changes are permitted to happen, there seems little doubt that the problems of the inshore waters will become more frequent and more distasteful. They also will be extended lakeward and gradually take over all of Lake Michigan.

There is no doubt that the factors

that stimulate eutrophication will function in Lake Michigan as they do in any other lake. There remains only the question--how long will it take? Whether this requires 50, 100, or 1,000 years, it can be prevented only by restoring the inshore areas to an acceptable state and preserving the offshore waters in their present state of purity. In the light of what is now known about Lake Michigan, a policy should be established without delay to keep nutrient input from all sources at the lowest possible level.

Summary

In summary then:

The offshore waters of Lake Michigan are now of high quality. They are just beginning to show slight, subtle changes in the direction of eutrophication. Localized inshore waters are now eutrophic and have lost their usefulness for many desirable purposes. If forecasts of future chemical inputs materialize, eutrophication processes will be accelerated. Problems in inshore waters will then become even more

distasteful and costly, and they will gradually involve the offshore waters. Accelerated eutrophication can be prevented if action to slow down nutrient input is taken soon enough. The Lake Michigan campaign can be largely a preventive one--therefore, more effective and economical than a totally restorative program. To restore the inshore waters and prevent the spread of inshore conditions lakeward, all controllable nutrient input should be stopped.

Thank you.

(Applause.)

MR. STEIN: Thank you, Dr. Bartsch, for a truly excellent and incisive presentation.

I know some of the panelists probably have known Fritz as long as I have, at least, when he just came out of Wisconsin. You have to realize that as an international expert there are a lot of demands on his time.

I wonder if we could get some comments or questions directed to him, because there are a lot of pressures for us to release him from Chicago as soon as we possibly can.

MR. OEMING: Mr. Chairman.

DR. A. F. BARTSCH

MR. STEIN: Mr. Oeming.

MR. OEMING: Dr. Bartsch, I first of all want to go on record to express my appreciation for a very enlightening report. This is the finest dissertation that I have heard in many a moon on this problem of eutrophication.

I have just two clarifying questions, Dr. Bartsch.

One, I wonder if you could define for us a little bit better what you mean by inshore and offshore. I don't mean that you should be precise, but could you give us some definition of this?

DR. BARTSCH: As I am using the term "inshore" here I mean primarily the shoreline areas which are used for recreation, which extend out as far as one goes for water supply. If I were to have to name the depth, I would say we are talking about somewhere in the neighborhood of 10 meters or less.

MR. OEMING: That is about what, 39 feet?

DR. BARTSCH: Yes.

DR. A. F. BARTSCH

MR. OEMING: Forty-foot depths?

MR. BARTSCH: In this general area.

MR. OEMING: I see. That is fine.

Now,(on page 713),Dr. Bartsch, you mentioned here that the phosphate input of soluble phosphate or the concentrations that you have found are .44 milligrams per liter, 15 times the concentration considered critical. Now, I wonder if you would just discuss that a little bit more.

First of all, could I assume from this that .03 you would feel is a critical concentration where you begin to develop these nuisance growths?

DR. BARTSCH: I think, Mr. Oeming, that one needs to be very careful about the terms and the words that are used when we are talking about critical concentrations of phosphorus, so I am going to be very careful in my answer to you.

We have evidence from at least four different directions that indicate first that if you have any phosphorus present you are going to grow some algae. The amount of algae

that you grow, all other things being equal, is directly related to the amount of phosphorus you have present. We all know about Lively's Law of the Minimum and this is what I am referring to. But we know from experience, we know from scientific inquiry that if you go beyond the level of about three-hundredths of a milligram per liter of phosphate, which comes out roughly to be one-hundredth of a milligram per liter of phosphorus, then we are supplying the system with enough phosphorus to grow nuisance growths of algae. And so we are talking here not whether you can grow algae at all, but the fact that when you exceed this amount you are on the threshold of growing enough algae so that they become a nuisance.

Now, we know this from observations that deal with circumstantial type of evidence--maybe Mr. Stein will quarrel with my use of that adjective--but indicate that in lakes where you do have phosphorus beyond this level of one-hundredth of a milligram per liter you have lakes which commonly are going to cause difficulties so far as production of nuisance

growths of algae are concerned.

I think there is another point related to this, and that is that if we want to look for the amount of phosphorus which is significant in this sense we have to determine the amount that is available at the beginning of the growing season and not at the time we have overgrowth of algae.

And then secondly, we also know that in cases where there has been intentional input of phosphorus for the purpose of improving production of algae, which it is desirable to do this, that we begin to grow substantial quantities of algae when you exceed this level of somewhere in the neighborhood of three-hundredths of a milligram per liter of phosphate.

In addition, we know from laboratory studies, and I am thinking especially of the studies that were done by Chu, if anyone here is familiar with him, or the studies that have been done by Rohde, that even under these cultural conditions and with some judgment it can be demonstrated that somewhere in that neighborhood you

have reached the point where you can grow substantial amounts of algae.

And then finally, fourth, we can also rely upon the cold logic of scientific facts. And I mentioned before Lively's Law of the Minimum, which may be familiar to many people here, which simply says that if you have a whole smattering of different kinds of nutrients in a body of water, a growth will take place and ultimately growth will be stopped because you exhaust one of these nutrients.

We know that most commonly phosphorus is one of these, and on the basis of this logic we can forecast that if you can cut phosphorus down to this level you are going to cut down the nuisance production of algae.

I am not sure that this answers your question.

MR. OEMING: It has done a very good job, sir.

I take it from what you said that we are talking about a ceiling of .03. You as a biologist don't want to see it go above this ceiling of .03, you would like to see it go

below this?

DR. BARTSCH: My own feeling with respect to Lake Michigan--and what I am giving back to you here is the distillation of having read all the reports that I could get my hands on and some awareness of this lake by having lived in its watershed and therefore having contributed to the problem myself--is a feeling that we have a wonderful lake here and if we increase the input of nutrients or if we allow the nutrients to go into this lake as they are now going into it, we can have no other effect except to increase the production of algae. And if you like clear water as it now is in the offshore areas, then, for heaven's sake, let's keep it that way and keep the nutrients out.

Because any direction you go from here toward increasing the nutrients is not going to keep this lake in the condition it is now in.

MR. OEMING: Dr. Bartsch, I had only two questions, but now you have led me into one or two more.

One of them is, you talk about controllable inputs here, and I think we are talking

now of phosphates primarily, phosphorus, would you expect a noticeable improvement in the situation if the phosphates were brought down, if this were the only thing that we attacked at this time? If we got the phosphates down to this .02 level, let's say, would that of itself produce a noticeable improvement in the situation?

DR. BARTSCH: I think actually I have already answered that in the former answer I made and I can only say yes, in the affirmative, again.

MR. OEMING: O. K.

DR. BARTSCH: I think this is the only direction you can go.

MR. OEMING: Fine.

Now, one more question, and this relates to your identification of areas on your maps in here. Do you intend to convey the impression that these are the only places there are problems or are there other places you haven't studied to identify that there are problems in existence?

I am thinking now of enforcement

programs, Dr. Bartsch, that while they are not mentioned in here, I think there are perhaps other places that would substantiate the need for an enforcement program.

DR. BARTSCH: I made no claim that the places that I cited were a complete expose. They reflect really the materials that were available to me in all of the reports I could get my hands on and study in the length of time I had. Undoubtedly there may be other places that I am not familiar with.

MR. OEMING: I would suggest that you talk with our man at the Federal office sometime. He can give you some more.

MR. STEIN: Are there any other questions?

Mr. Klassen.

MR. KLASSEN: I want to add my compliments to this excellent paper.

I have three questions, Mr. Chairman.

One, could you outline some of the eutrophic parameters that we could possibly look to as a means of measuring whether the lake is increasing in the aging process,

decreasing, and also one of the latest, this aerial surveillance method which recently has been reclassified.

The second question, could you outline what are some of the control measures? You talk about control. What are currently the practical control measures that we could use?

And the third, it hasn't been mentioned, what is the role of sodium in this whole eutrophic process? It is my understanding, and I have a publication here, there are certain types, particularly the bluegreen algae, that will not grow unless sodium is present. What is the role of sodium? Because sodium is found in Lake Michigan.

DR. BARTSCH: In response to your first question, Mr. Klassen, there are a number of parameters that one could look for, and certainly I would hope, regardless of where we go from this day on with respect to Lake Michigan, that we would have some way of keeping a finger on the pulse of what happens in this lake.

To do this I would say first we ought to have a surveillance program over the quantity of production in this lake in terms of algae. You recall I said this is one of the principal symptoms of eutrophication. And I think that this ought to be a continuing surveillance so that we know whether we are getting ahead or, even more important, whether we are falling behind on this aspect.

I would say that we should have some continuing assessment of what is happening to the levels of oxygen at the bottom waters, because you recall that depletion of the deep water oxygen is one of the symptoms of eutrophication. We can point to it in many other places where this is one of the most evident types of scientific data that can be looked at.

I think in conjunction with it we would want to look at phosphorus levels in the deep water, because often times we find that as the oxygen depletion occurs we get a buildup in phosphorus, and there are reasons for this that we could go into.

I would think we would want to have

some awareness of the nature and the rate of exchange of nutrients between the bottom sediments and the overlying water.

And in connection with your comment on aerial surveillance, this is an area in which we feel we should be doing some research, and in fact I have a colleague who took off and went out to the O'Hare Field last night to have dinner with two men who represent a company who are doing research in this area. Maybe we will get out into outer space and have some surveillance from that vantage point or maybe we will stay closer to home and just use aerial surveillance, the laser, and all the sophisticated approaches that we can now think of.

MR. KLASSEN: The second was on the control methods.

DR. BARTSCH: Yes. So far as control is concerned, I prefer not to discuss this in detail because Dr. Weinberger is going to follow me once removed and I believe he is going to cover this.

But I would want to say before leaving the control that while we talked about roughly

two-thirds of the phosphorus having its origin in wastes, municipal and otherwise, I think we should not ignore the other one-third, because it seems to me foolish to consider the tremendous expenditure involved unless we are going to plug all of the leaks that we possibly can. And to me this means that--I assume we do not now have the technology to control phosphorus runoff from cultivated land, and infiltration through agricultural practices. I think here is an area in which there needs to be some work, some research, some development in order to be able to plug this source of input. I understand that at the Secretarial level there nave been discussions about things that might be done in order to develop programs in this direction.

So if this is acceptable, I will stop my comments on control at this point.

On the matter of sodium, sodium is one of the necessary micronutrients for the production of algae. It shares a distinction, therefore, with molybdenum, copper and zinc and boron and a number of metals, and to assume that sodium has any extraordinary role beyond

that I think is not supported by any scientific knowledge that I have. This is the same as saying that sodium in its requirement, or the requirement of the algae for sodium, lies at such minute concentrations in the medium that I think we would find sodium everywhere in every water in the United States.

MR. KLASSEN: Like Mr. Oeming, you lead me into one more question.

You mentioned about the bottom deposits. Is there in the bottom deposits a necessary ingredient to form a type of vitamin, especially vitamin B_{12}, that is necessary or encourages the growth of vitamins? My basis for this question was a lecture by Dr. Liebman, who I am sure you know, in a Munich biological institute. Is this a problem that we might be facing in Lake Michigan?

DR. BARTSCH: I can't speak to that point authoritatively, but I can point out to you that all the algae, so far as I am aware, require vitamin B_{12} in the metabolism, but I also have the impression that vitamin B_{12} is available from other sources. We know it comes

from sewage, for one thing. But it is also produced in the environment by bacterial action and there is even some question whether blue-green algae may not be able to produce some themselves.

MR. KLASSEN: Thank you.

MR. STEIN: Mr. Poole, did you have one?

MR. POOLE: First I want to add my commendation to Dr. Bartsch. Fritz, this is the most lucid explanation that I have heard for the last several years.

My question is, am I correct in assuming that in your judgment eutrophication is the major overall problem we are facing as far as pollution of Lake Michigan is concerned?

DR. BARTSCH: Well, I may have to be a little coy in answering that because eutrophication is my principal occupation, and therefore I would say on that basis, yes, that as far as I am concerned there is no question that this is the real pressing problem of Lake Michigan.

Moreover, it is the kind of problem that doesn't go away by itself. And to me the

prospect of losing a lake like Lake Michigan because we fail to keep nutrients out and because we fail to control eutrophication, which may be only one aspect of the overall problem, means that in any event we are going to lose the lake.

And so on that basis, I would say very definitely, to me it is the most important problem as far as Lake Michigan is concerned.

MR. POOLE: I have just one more, and I think I merely want you to reiterate the answer you gave to Mr. Oeming.

Am I correct in assuming that in your judgment the proper attack on this problem is to beam the attack at the removal of phosphates?

DR. BARTSCH: Yes.

MR. POOLE: Thank you.

MR. STEIN: Are there any questions down here?

Mr. Poston.

MR. POSTON: I have a question here relative to clarification. Mr. Oeming asked us the question or asked Mr. Schneider to read the sentence about "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." And I note that our thrust in this statement was intended to indicate that there is not a major oxygen problem in Lake Michigan.

In your statement (on page 708) in your presentation you talked about dissolved oxygen concentrations and I wondered if there is any difference in our presentation or our statements here.

DR. BARTSCH: I am not sure I get the exact sense of your question, but let me comment as I think the answer ought to go.

The data that I referred to on oxygen depletion in the bottom waters I cited here only as one of the subtle symptoms of the beginnings of eutrophication, and when we talked about the number of occasions of sampling when we find that the oxygen level is something slightly less than 90 percent of saturation, which is the context of what I said, then I wouldn't consider this to be a serious deficiency from

the ordinary point of view.

It is serious only in the sense that it says to us, look here, there is something wrong in this lake, and it is not saying to us, look here, we have depleted the oxygen to the point where we are having serious problems because of it.

Does that answer your question?

MR. POSTON: I think so. What you are saying is that there is some below saturation, times when there is--

DR. BARTSCH: Yes.

MR. POSTON: --less than saturation with respect to oxygen?

DR. BARTSCH: Yes.

MR. STEIN: Any other questions?

Mr. Holmer.

MR. HOLMER: Dr. Bartsch, I enjoyed this seminar and I think we can learn quite a bit from it. I hope that this question will be one that you won't have to refer to your chauffeur to answer because it is too simple.

The definition of sources of phosphate entry into Lake Michigan includes both those which

can be clearly identified, the municipal and industrial sources, and the non-municipal, non-industrial. Has there been an analysis that would give us some idea of the proportionate shares of these in the total input?

DR. BARTSCH: Yes. I have some data like that here, I think.

I have three figures. One is land runoff, which was estimated to be 4.9 million pounds per year, discharges directly to the lake, those that have a sewer outfall directly to the lake, 5 million pounds, and the tributaries 9.7 million pounds.

Now, in the tributaries we have reflected here also those municipal discharges that happen to occur in these tributaries.

MR. HOLMER: Thank you very much. About half, then, roughly, comes from non-point sources, we might infer from these figures?

DR. BARTSCH: It would be somewhere in that area, yes.

MR. HOLMER: The other question I have, we have indicated that there is a critical point in the amount of phosphorus measured in

parts per million. Would there be any virtue in thinking in terms of increased diversion of water into Lake Michigan in order to increase the water content or does it all run out the other end so that this wouldn't help us in reducing the parts per million?

DR. BARTSCH: I think I can only answer that by saying that the idea of dispersing nutrients by input of a billion is not a new idea, and we in our research program at the moment are planning for such a project which we will carry out in Moses Lake, Washington, this coming summer, in which we will use water which is of low fertility diverted from the Columbia River to introduce into one arm of the lake for this kind of study.

To think about this in relation to Lake Michigan is of a magnitude that I just can't grasp at the moment. I think there are too many other factors that would have to be examined in terms of the percentage or the ratio of the amount of water you could get your hands on to introduce for this purpose in relation to this tremendous reservoir of water you have

here already.

To say it a little differently, in Moses Lake we contemplate completely replacing the water in one arm of the lake. I can't visualize that you could ever get your hands on enough water to do this in Lake Michigan. At the same time I think the principle is a reasonable one to explore.

MR. STEIN: We have some other questions here.

You know, it is a delightful suggestion to some of us in the water field, particularly to those who have spent their whole careers and will probably retire on the Chicago diversion case, (laughter) but something like that will keep us busy and our children busy, I guess.

Do we have a question down there?

MR. POOLE: Well, first I commended Dr. Bartsch on his report and now I want to argue with him a little.

If I understood his answer to Mr. Holmer, he was saying that about half of the phosphorus in the lake came from what I choose to call non-point sources, and this is not

what he has in his report (on page 703), where he says a third and two-thirds from municipalities and industries. Based on having gone through this in the Lake Erie conference, I have been carrying around in my head for a long time that at least the two-thirds figures did come from point sources.

DR. BARTSCH: Yes, I believe I misspoke in response to you, a misinterpretation in going through this table.

MR. STEIN: I think that stands corrected.

Are there any other comments?

MR. MITCHELL: I would like to ask a question.

On page 712 you state that, "The growth of such masses of algae is a direct response to concentrated high levels of nutrients brought into the lake by way of municipal sewage, land runoff, urban drainage, industrial wastes."

Are those listed in the order of their contribution?

DR. BARTSCH: No, not necessarily.

MR. MITCHELL: What would you suggest

that order might be?

DR. BARTSCH: I could only give you a rough impression, and I would say here that municipal sewage very likely might be the major one, but I am not sure. If you wish, I would be very happy to arrange to get some correct figures on this and see that they come to you.

MR. MITCHELL: I would appreciate it.

MR. STEIN: Mr. Holmer.

MR. HOLMER: I have one minor question.

When you used Dr. Hasler's chart of eutrophication, which shows the two rather sharp curves, it was my impression from what you were saying that we are really in the leading edge of the very first upward curve toward eutrophication. Is this a correct interpretation of what you are saying?

DR. BARTSCH: Yes. I would say that so far as Lake Michigan is concerned, we are just at the point where the effect of this is becoming visible.

MR. HOLMER: In terms of geological

time, this is a fairly extensive period except for what man does to accelerate the process, though?

DR. BARTSCH: Will you restate that? I didn't quite hear it.

MR. HOLMER: In terms of were man not accelerating the process by which we move up that curve, it would even at that stage represent a significant series of millennia in all probability?

DR. BARTSCH: I wouldn't want to be one to forecast, and I very carefully did not forecast in my statement--

MR. HOLMER: I know you didn't.

DR. BARTSCH: --when this lake is going to reach X stage of eutrophication. But I would say this, that if we compare Lake Michigan with Lake Erie, I think we have to recognize that there are two antagonistic situations. For one thing, Lake Michigan is exceedingly deep and, therefore, the quantity of water in relation to the surface area, which is one thing you look at in connection with eutrophication, is exceedingly great. This

would tend to deter or slow down the rate at which eutrophication takes place except for the second, and that is the fact that we have in Lake Michigan, as it has been called, a cul-de-sac type of lake, and although we have seen some estimates that the flushing rate might be a hundred years, I think Dr. Baumgartner, who is going to follow me on this rostrum, is going to indicate an estimate of a much longer period of time than that for complete flushing of Lake Michigan.

So on this basis, it means that it might be going at a faster rate, if you look at this part only, than in Lake Erie.

Now, to get directly to your question, I think that if we stay right where we are now that it might be a long, long, long time before we really reach a stage in Lake Michigan that you could think of as a highly eutrophic rate so far as the entire body of water is concerned.

MR. STEIN: Mr. Poston, do you have one?

MR. POSTON: I would like to ask Dr. Bartsch whether there are materials discharged

from municipal and industrial outfalls that would affect the lake proper, that is Lake Michigan, even though these discharges may be at remote parts of the Basin, such as 50, 100 miles' distance?

DR. BARTSCH: I think what you are asking me really is does the phosphorus discharge from X city on X tributary find its way into Lake Michigan, and I think obviously the answer is yes and this can be demonstrated through stream surveys, and we have an indication here that there is already a tremendous input of phosphates into Lake Michigan by way of the tributaries.

MR. STEIN: Are there any other comments or questions?

I think we have another one here.

Go ahead.

MR. OEMING: Dr. Bartsch, have you made any evaluation or estimate of the contribution of phosphates from the massive die-off of alewives in Lake Michigan?

DR. BARTSCH: No, I have not.

MR. OEMING: Would you think that that

might be desirable, to have some information about this? Even though we might not be able to do anything about it, I think it would put this into some perspective here.

DR. BARTSCH: I think it would be interesting to have some awareness of how much nitrogen and phosphorus and iron and other elements are bound up in the bodies of the alewives, but from a practical point of view it seems to me that all we are really talking about here is an acceleration of the natural recycling of the nutrients within the lake system itself.

MR. OEMING: It comes after the growing season, doesn't it, what you term the growing season, this contribution, so from your standpoint would it be significant?

DR. BARTSCH: In the lake we have a recycling going on all the time.

MR. OEMING: I know you have.

DR. BARTSCH: So long as there is growth in production of algae and the other microscopic animal organisms that go along with them, we have recycling of phosphorus

and other nutrients through the system.

MR. OEMING: I see.

MR. STEIN: Are there any other comments or questions?

You know, Secretary Edwards this morning read a letter from a young man to Secretary Udall indicating the interest in the program. What this brings home to me here is the size of the group that we are talking to and the interest here. I can remember the day when they had all the so-called specialists in one dinky old corridor in the building and we used to talk to each other. I think we have come a long way since then.

Thank you very much, Dr. Bartsch, for an excellent presentation.

(Applause.)

MR. STEIN: We will stand recessed until 2 o'clock.

(Whereupon, a recess was taken until 2:00 p.m. of the same day.)

AFTERNOON SESSION

(2:00 p.m.)

MR. STEIN: May we reconvene?

Before we get into the afternoon session, we sometimes refer to the industries here as clients. To give you an indication of what is done, I think we will take a few minutes to call on Mr. Mallatt of American Oil.

Mr. Mallatt, will you come up for a moment? I think he has a couple of slides to indicate what American Oil is doing.

Why don't you take the rostrum.

INDUSTRY PRESENTATION

MR. STEIN: I don't know if any of you people have seen the American Oil Refinery, but they have done a rather thorough job of pollution control. They are just not satisfied with ordinary pollution control; they are researching and going on further.

Mr. Mallatt.

INDUSTRY PRESENTATION

STATEMENT BY R. C. MALLATT
COORDINATOR OF AIR AND WATER CONSERVATION
AMERICAN OIL COMPANY, CHICAGO

MR. MALLATT: Thank you very much, Mr. Stein.

In view of the reference this morning to a vessel stranded in Lake Michigan that contains some bunker sea fuel and thereby the indirect reference to the general problem of recovering oil that may be spilled by accident in water, I thought that there might be some interest in seeing a slide or two of an oil recovery craft that we have developed in recent weeks. An announcement of this device will be released to the press this afternoon and it probably will appear in some of the papers tomorrow.

If we can have the first slide, please.

This is the vessel. It is an 8-foot wide by 24-foot long catamaran boat that is propelled with an outboard motor. Mounted amidship in this craft is a new device for

for removing oil from the surface of the water. It consists, in essence, of a steel drum, to which is affixed a blanket of polyurethane foam, which has an affinity for oil. It is driven by a conventional two-cylinder engine and can be raised and lowered, depending upon the depth of the layer of oil in the water. As this revolves it picks up the oil from the surface of the water and passes the belt with the contained oil through the first of two rollers. By applying light pressure to the first of two rollers, which cannot actually be seen, we first squeeze out the contained water, and then in the second roller, by applying more pressure, we squeeze out the oil. By this means we are able to recover this oil-water mixture in a form that concentrates the oil. In other words, the stuff we recover contains about 95 percent oil and maybe 5 percent water instead of the reverse, which is usually the situation.

Under actual operating conditions, this particular size craft and roller should have a capacity for picking up about 50 barrels

of oil per hour. Of course we anticipate using this in connection with these floating booms, which usually are used to surround the oil and contain it, and then by going in with this device we expect to pick it up. We have just the one craft now. We are making four more at the present time.

Thank you, Mr. Stein, for the opportunity of calling this to your attention.

MR. STEIN: Thank you.

You know, to show you the relationship of the industries and the regulators, I once got a gift from American Oil and you know what that was? They sent me an extra copy of the credit card. My older girl is now a senior in college and I made the mistake when I got that extra credit card of giving it to her. That was the most expensive gift I have ever had.

(Laughter.)

(The following material was submitted by Mr. R. C. Mallatt:)

R. [illegible]ALLATT

NEWS

American Oil Company

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For Publication A.M. Editors, Friday, February 2, 1968.

Development of a new device to help clean up oil spills in harbors and on lakes was announced today by American Oil Company, marketing, manufacturing and product research subsidiary of Standard Oil Company (Indiana).

The new oil skimmer was described as "The most effective device built to date for the cleanup of oil spills," by Dr. Philip C. White, American Oil's vice president in charge of research and development.

The new oil skimmer, mounted on a 24-foot pontoon catamaran, consists of a

"super-sponge" made from hydrophobic polyurethane foam mounted on a 4-foot-long, 12-inch-diameter rotating drum. It soaks up spilled oil from the surface and repels water. Whatever little water it absorbs is squeezed out with low pressure rollers. The oil then is removed by applying greater pressure.

"This device can clean up to 50 barrels of spilled oil per hour," Dr. White said. "The recovered oil then is stored in a large plastic 'sausage' towed by the catamaran, and later taken ashore for treatment."

Pontoons and specially designed baffles lessen the effects of water turbulence and permit the catamaran to scoop up oil even in mildly agitated waters.

The skimmer was developed by Engineers Robert Yahnke and Robert Will at the Whiting, Indiana research laboratories of American Oil.

"Our tests indicate that the device works well with either heavy, viscous fuels or lighter oil products, making it useful for any type of petroleum spill," Dr. White said. Development of the skimmer results from the

the company's continuing air and water conservation research.

Several additional skimmers are under construction at Whiting, and will be kept in readiness at the company's major marine terminals. They will be made available to other oil companies, the Coast Guard and other public agencies to help deal with any oil spillage accidents, Dr. White said.

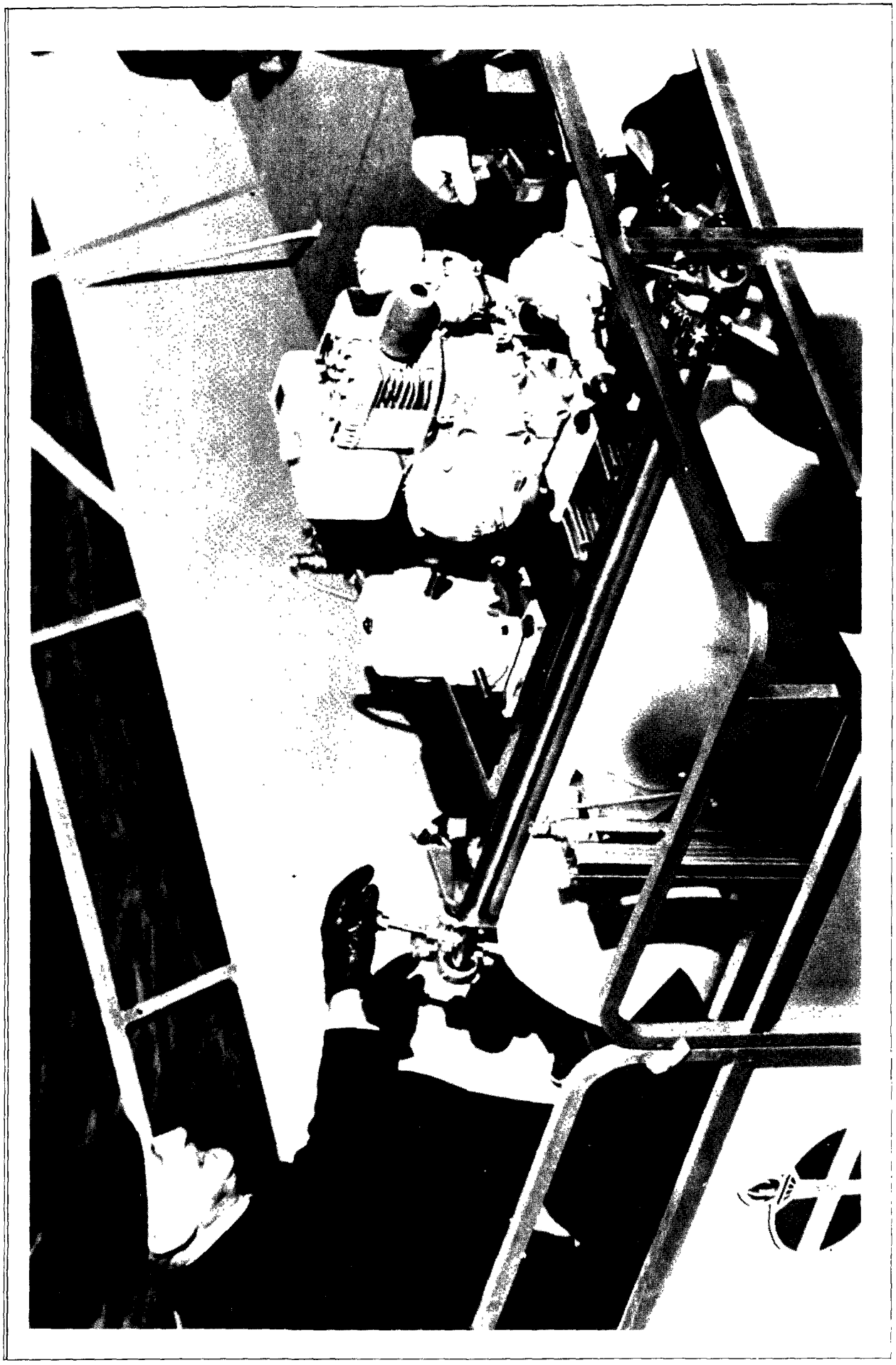
The new skimmer will be used in conjunction with floating slick bar booms which can effectively corral and contain spilled oil in waters where the surface current is slow, according to R. C. Mallatt, American Oil coordinator of air and water conservation. These plastic barriers also can be used to funnel spilled oil away from beaches and into areas where it can be scooped up by the new skimmer or other devices.

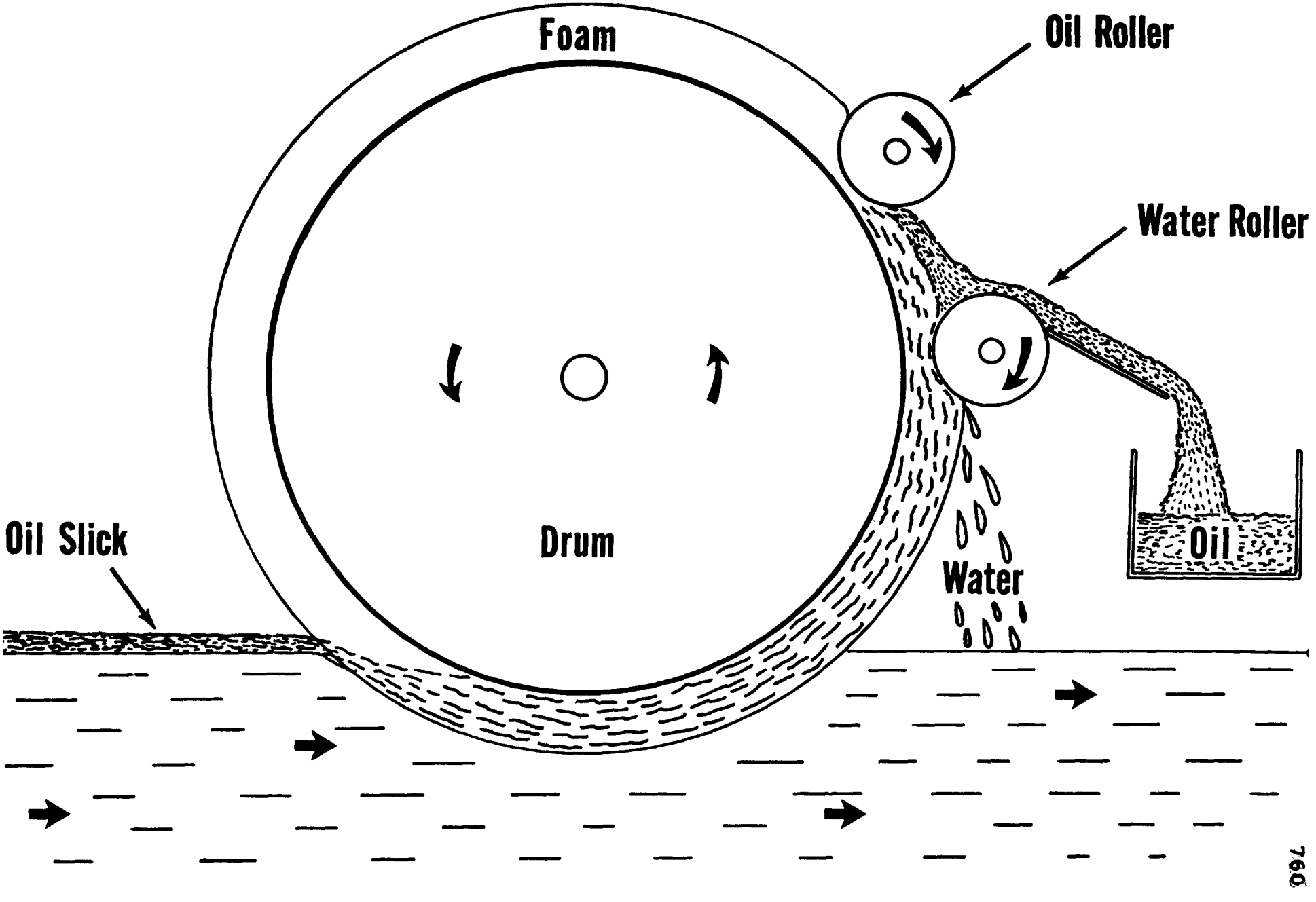
- - -

Lines for art

R. C. Mallatt, left, American Oil Company coordinator of air and water conservation, demonstrates new oil skimmer, installed

in an outboard-motor-powered catamaran. Polyurethane-covered drum (foreground) rotates toward camera, absorbing floating oil which is squeezed out of the foam material by metal roller located just above drum. Small amount of water picked up by foam is removed from drum by a low-pressure roller (out of sight behind drum), before it rotates under oil-removal roller where greater pressure is exerted. Oil squeezed out of the foam is stored in a plastic container towed behind the catamaran, and later taken ashore for treatment.




Foam
Oil Roller
Water Roller
Oil Slick
Drum
Water
Oil
760

FEDERAL PRESENTATION (CONTINUED)

MR. STEIN: Mr. Poston.

MR. POSTON: Mr. Chairman, we are ready to hear from Dr. Donald Baumgartner, our Senior Oceanographic Scientist, and he will tell us about the currents in Lake Michigan.

Dr. Baumgartner.

STATEMENT OF DONALD J. BAUMGARTNER
CHIEF OF OCEANOGRAPHY
PACIFIC NORTHWEST WATER RESEARCH LABORATORY
CORVALLIS, OREGON

DR. BAUMGARTNER: Thank you.

Mr. Chairman, Conferees, my name is Donald J. Baumgartner.

The purpose of my statement is to provide information on the currents in Lake Michigan and to explain how they relate to the transportation of pollutional material throughout the lake. With this explanation you will see that it is necessary to consider all of Lake Michigan within one water pollution control scheme, since pollutional material discharged at any point in the lake can contribute

to degradation of water quality at any other location. This conclusion is reached after a general consideration of factors which influence motion in large bodies of water, coupled with specific scientific studies conducted on Lake Michigan.

THEORETICAL CONSIDERATION

In presenting a brief review of these considerations, six factors come to mind: wind, atmospheric pressure, topography, solar radiation, precipitation, and the rotation of the earth.

All bodies of water presenting a free surface are set in motion by the winds which blow over them. Water near the surface is dragged along with the wind, in turn dragging with it water below the surface, until encountering some obstacle, such as the shore. Here the surface currents may be diverted along the shore in either direction or downward toward the bottom, returning toward the region where they were initially produced. When the wind patterns are small with respect to the size of the lake, the

resulting current pattern would be neither simple nor uniform. What's more, the wind patterns change from day to day; hence, circulation patterns established yesterday are not necessarily those which would be established under today's wind. The surface waters respond first with a change of wind, and they in turn transmit the change to the deeper waters, causing in the process some turbulent mixing of the layers.

Another factor associated with the weather, which requires consideration, is atmospheric pressure. Just as the liquid level in a barometer rises or falls with changing pressure, the water level at one end of the lake tends to rise or fall with respect to the other end under conditions of variable pressure. With a relatively fixed volume of water in the lake, this can only be accomplished with a flow of water from one end to the other, causing, of course, a current.

A third factor of importance in considering currents is the shape of the bottom and sides of the lake basin. Upon close examination of Lake Michigan's shore,

we find harbors, breakwaters, coves, shallows, and tributaries which have an influence on the currents in each locality. More generally, current patterns show the influence of two ridges extending northeast across the bottom of the lake, north and south of Milwaukee. This prevents the deeper water from flowing in an uninterrupted north-south path, and causes a great deal of mixing as water flows up and over the obstruction.

The fourth item to be considered is the amount of solar radiation which falls upon the body of water. As the sun's rays pass through the water, more of the energy is absorbed near the surface than at subsequently lower levels, resulting in an uneven increase in temperature with depth. When water is above 39° Farenheit, further increases in temperature cause a decrease in density; hence, water near the surface becomes lighter than the deeper water. Because of this decreased density, the warmer water tends to float, almost as if it were a different liquid, and resists mixing with the colder, more dense water beneath. Starting with the onset

of summer, the situation begins to intensify as the summer progresses. With more and more heat added to the surface of the lake and being mixed only to a relatively shallow depth, the colder waters below remain relatively unaffected. The zone of separation between the warm, less-dense surface water and the cold, deep water is frequently referred to as the thermocline, and while it is not as distinct a separation as would be found with oil floating on water, there can be a rather definite demarcation of the two bodies of water to the extent that they act as though they were separate layers. Even though both are water with very nearly the same composition, there is very little interchange of material from one layer to the other. A significant aspect of this type of two-layered system is that waves can exist on the interface between the two layers just as waves exist on the surface of the water.

The most readily apparent current is that caused by all the water introduced to the watershed by precipitation, flowing toward the

outlet, which in the case of Lake Michigan averages about 25 billion gallons per day. In small lakes with large inflows, this may be the principal cause of currents, but even flows this great are not expected to predominate in large lakes over currents caused by other considerations.

The above characteristics are common to all bodies of water and are firmly established in the scientific literature and in textbooks on limnology and oceanography. Currents consistent with these concepts have been actually observed and documented by investigators in this country and abroad, both in lakes smaller than Lake Michigan and in bodies of water larger and of a different shape than Lake Michigan. There is, therefore, no reason to expect that the currents occurring here would not exhibit the same general features.

The rotation of the earth contributes to currents in large lakes such that parcels of water moving under the influence of forces previously mentioned would be deflected to the right (when viewed from above). Thus any

water otherwise motivated to travel in a rather direct line from, say, Milwaukee to the Straits of Mackinac, would actually follow a curving path to the right toward the eastern shore.

Before mentioning the observations which have been recorded on the type of currents actually found in Lake Michigan, I should point out one factor specific to this system which contributes to the complexity to be expected in the flow. The connection between Lake Michigan and Lake Huron, while admittedly narrow, is a free connection, thus flow patterns in one lake can influence the flow in the other through this channel.

When one considers the almost unlimited variety of pressures and wind systems, temperature and precipitation phenomena which can exist over this lake system and how it can vary from day to day, one would not be surprised to observe a great variation in the current regimes. With this introduction, there are two questions which remain to be answered--first, what has been observed which would demonstrate such a complex current system; and second, what does this mean

with respect to the fate of pollutants in the lake.

SPECIFIC OBSERVATIONS

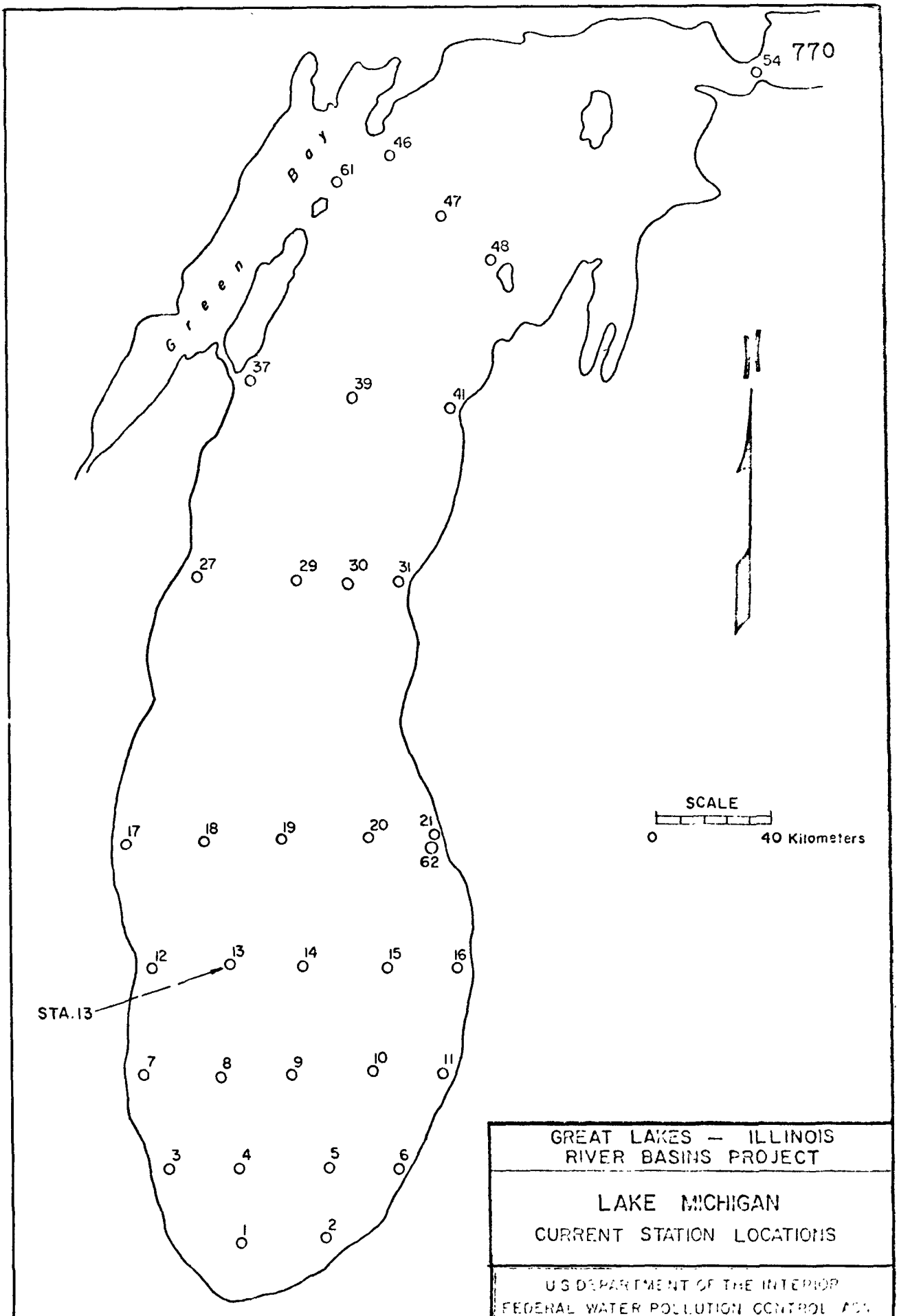
A large number of scientific investigations have been conducted in Lake Michigan to ascertain the currents which result from the interaction of these various factors and to determine which, if any, exert the dominating influence. One of the most extensive and most recent studies of this nature was made by the staff of the Great Lakes Region of the Federal Water Pollution Control Administration and is described in a report entitled, "Lake Currents" A major portion of the field investigations was performed under the direction of Mr. James L. Verber, who has extensive experience in studying lake currents. In addition to the contributions of other technical staff in the Federal Government, contributions were made by well known scientists from universities throughout the country.

Because of the size of this report, Mr. Chairman, I will not request that it be

made a part of the record. However, copies are available in the Regional Office of the FWPCA here in Chicago for review by interested parties.

(Copies of Exhibit 5, a report titled "Lake Currents," are on file at the Federal Water Pollution Control Administration in Washington, D. C., and at the Regional Office in Chicago, Illinois.)

DR. BAUMGARTNER: One of the major objectives of this study was to provide information on the variability of currents at different times of the year throughout the lake. To do this, current meters which recorded the direction and speed of the water mass were anchored at the locations indicated on figure 6-2 of the report, which is reproduced on the first slide. At each of the stations indicated on this figure, current meters were installed at various depths, the number depending upon the depth of the lake at that location. Many of the same stations had temperature recorders at various depths and wind meters floating on the surface. In some cases data were recorded for over 200 consecutive days. With this amount


770
54
46
61
47
48
Green Bay
37
39
41
27
29
30
31
17
18
19
20
21
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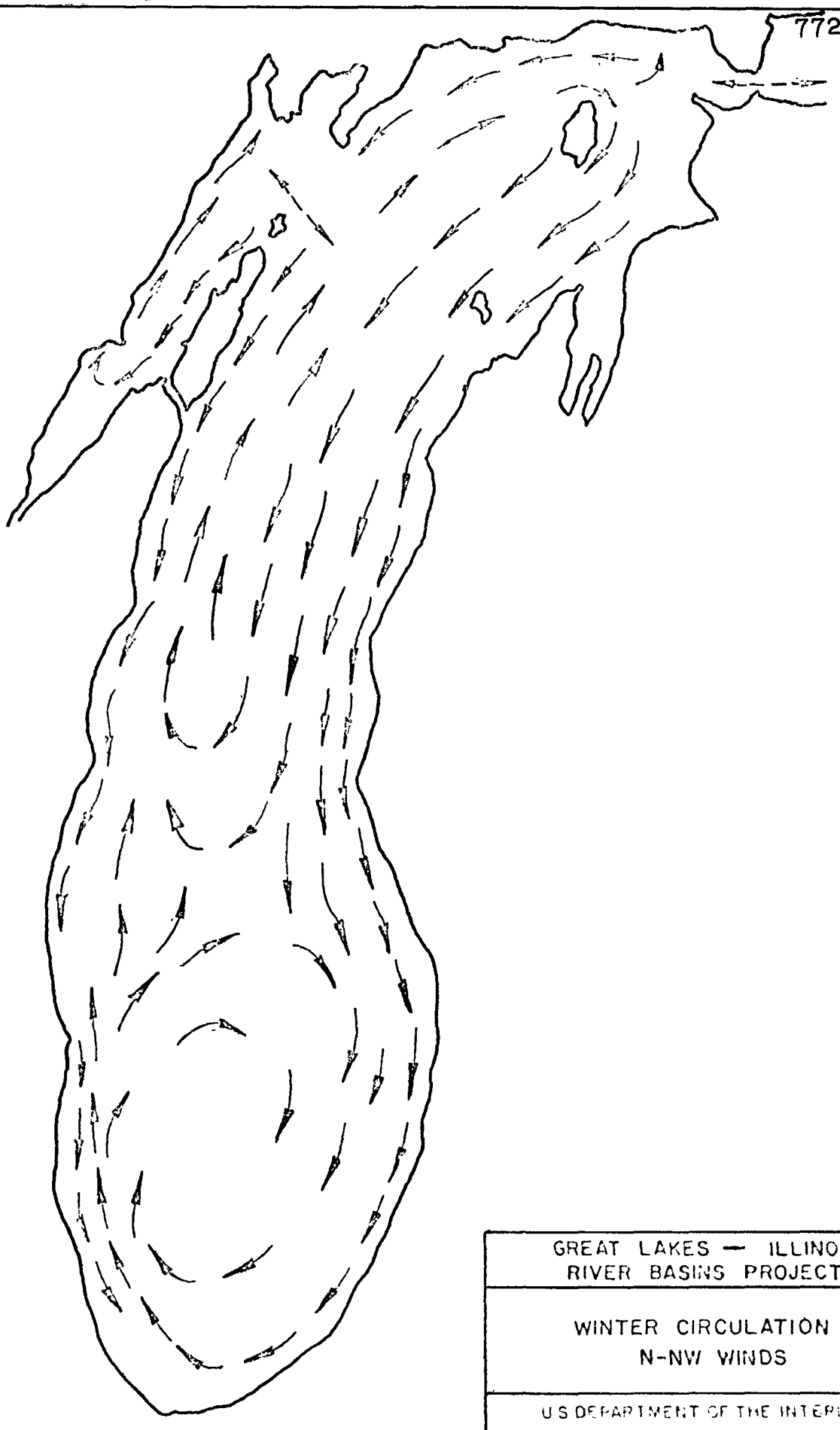
12
13
14
15
16
STA. 13
7
8
9
10
11
3
4
5
6
1
2
SCALE
0
40 Kilometers
GREAT LAKES — ILLINOIS
RIVER BASINS PROJECT
LAKE MICHIGAN
CURRENT STATION LOCATIONS
U S DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL
Great Lakes Region
Chicago

FIGURE 6-2

of information, it was possible to observe the nature of currents at any one station over a considerable range of weather conditions and lake temperatures, and also to compare currents obtained at other locations to give a picture of the general circulation pattern at any one time. This type of information was most complete for the current meters near the surface, which in this context is meant to be at a depth of 10 meters. In conjunction with the wind data it was possible to determine four general types of circulation in the surface waters, related to the wind and the presence or absence of a thermocline in the lake.

In figure 6-4, shown in the next slide, current patterns are depicted by a series of arrows. As you will note from the caption, this is the type of surface current found in winter under the influence of winds coming from the north to northwest quadrant. This type of flow usually predominates from November through March, although it is subject to variations for short periods of time under changing weather conditions. In total, it



GREAT LAKES — ILLINOIS
RIVER BASINS PROJECT

WINTER CIRCULATION
N-NW WINDS

U S DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Great Lakes Region Chicago, Illinois

can be expected to occur about 25 percent of the year. I would call your attention to several features--at the upper end of the lake, the double-headed arrow indicates that the flow is considerably variable at this point, influenced not so much by the winds over the rest of the lake, but by surging of water back and forth between Lake Michigan and Lake Huron. This type of situation was reported by C. F. Powers and J. C. Ayers of the University of Michigan in 1960.[1]

The southern end of the lake is dominated by a clockwise rotational flow, being separated from a rotational flow in the northern section of the lake on a line running approximately northeast from the region south of Milwaukee. Immediately offshore from the Chicago area, the flow appears to be southward near the shore, but northward a short distance farther offshore. The separation of the rotational

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1/ "Water Transport Studies in Straits of Mackinac Region of Lake Huron", by Charles F. Powers and John C. Ayers. Limnology and Oceanography, Vol. 5, pp. 81-85, January 1960.

pattern in the southern end of the lake from that in the northern end will be noticed in the subsequent slide. The flow offshore from the Chicago region will also be compared to the situation observed here.

The next slide, figure 6-5, shows winter conditions where the wind is from the south to southwest quadrant. These winds are commonly found from January to April and hence overlap the same period of time under which the previous current regime is demonstrated. This again accounts for flow in approximately 25 percent of the year. Directing your attention again to the Chicago area, it is seen that the near-shore currents and the offshore currents are reversed from the circulation indicated under conditions of winds from the north-northwest.

In the next slide, figure 6-6, the current pattern is depicted for the rather rare circumstance of winds from the north-northeast, which occurs about 10 percent of the year, mainly during the summer. The circulation in the central part of the south end of the lake is again a counter-clockwise rotation,

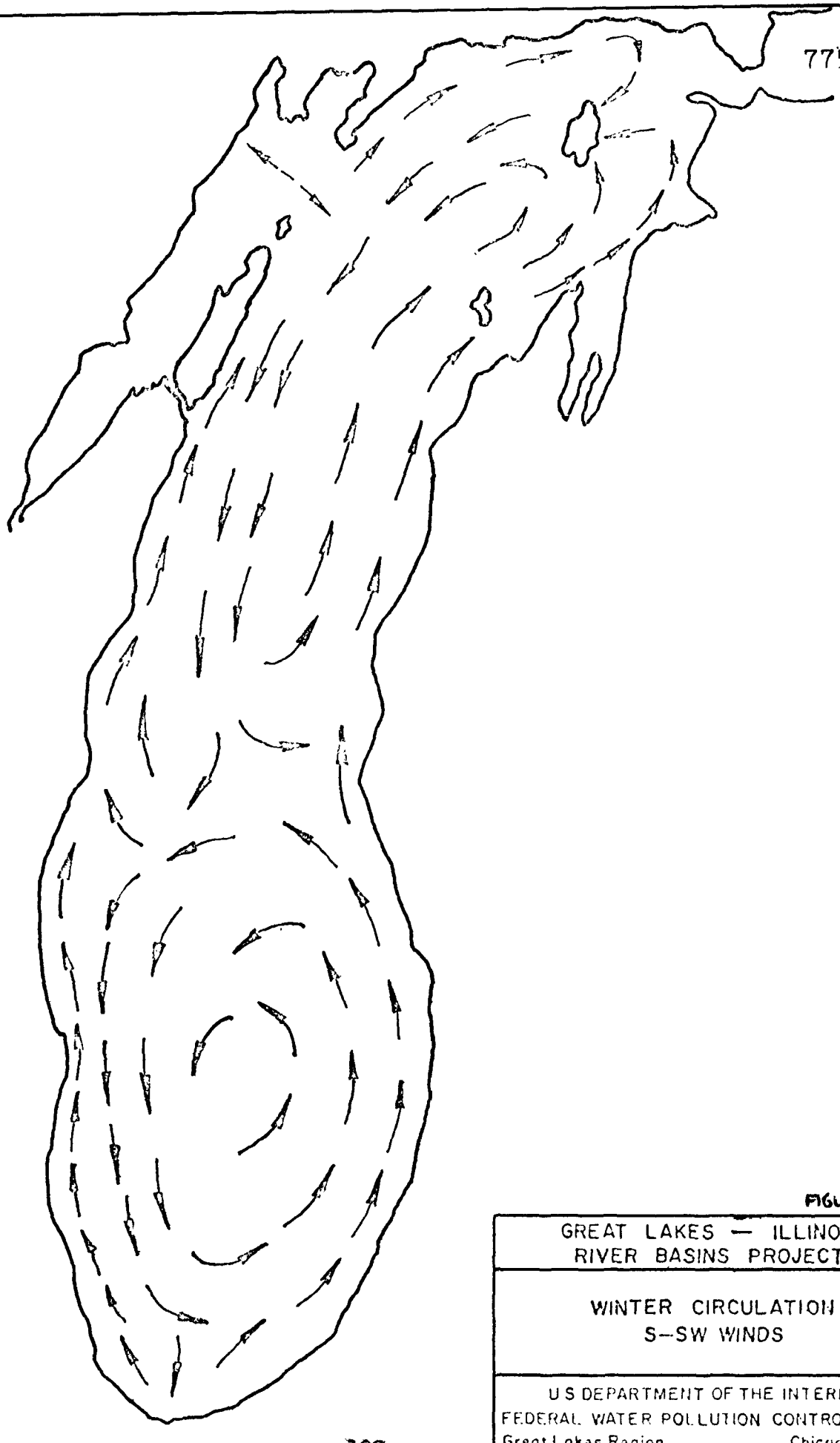


FIGURE 6-5

GREAT LAKES — ILLINOIS
RIVER BASINS PROJECT

WINTER CIRCULATION
S–SW WINDS

U S DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN
Great Lakes Region Chicago, Illinois

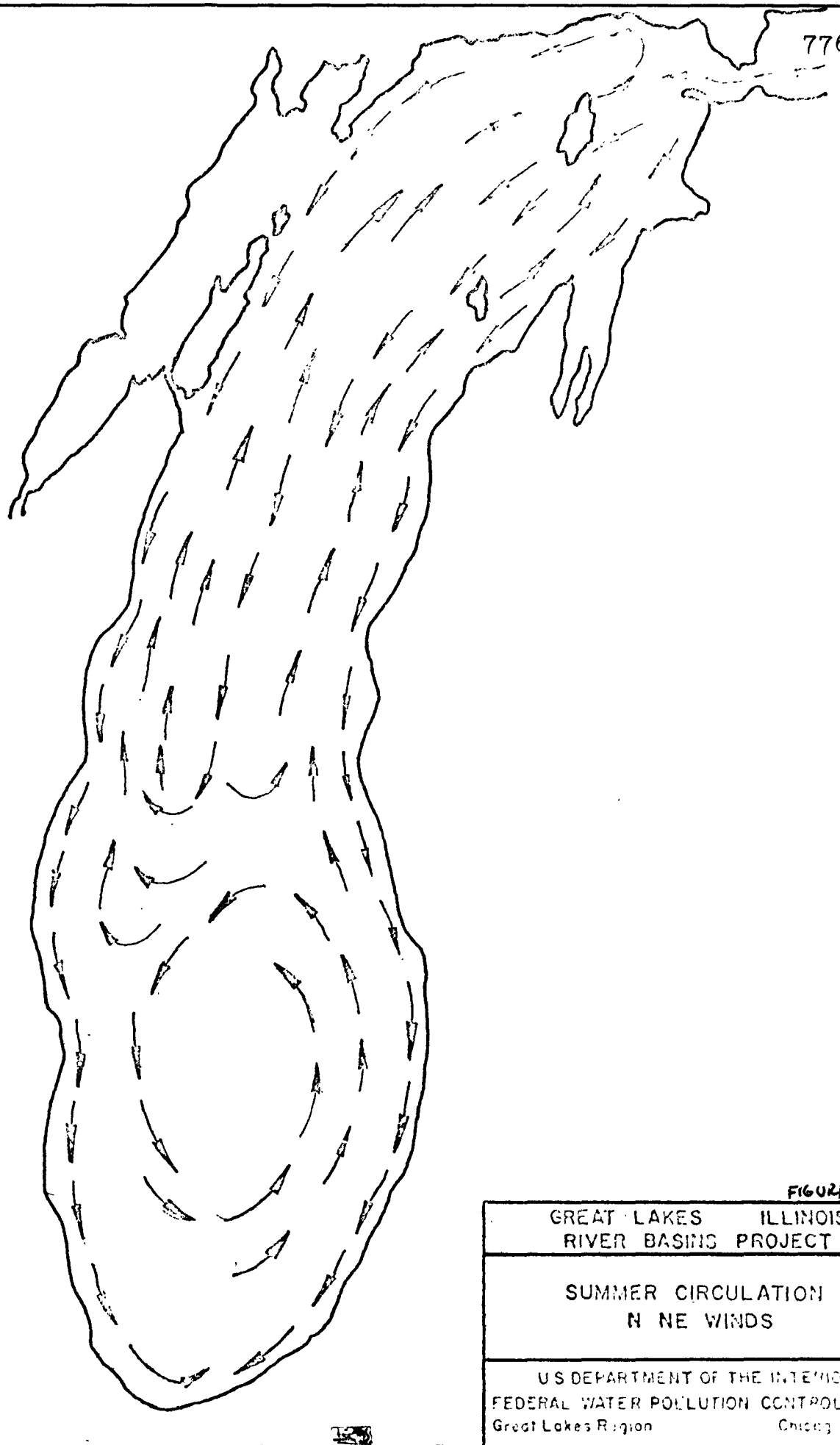


FIGURE 6-6

GREAT LAKES ILLINOIS
RIVER BASINS PROJECT

SUMMER CIRCULATION
N NE WINDS

U S DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN
Great Lakes Region Chicago, Illinois

and offshore from Chicago the nearshore direction is the same as the rotational flow.

The next slide, figure 6-7, shows the dominant summer circulation, which occurs about 40 percent of the year under the influence of winds from the south-southwest. The circulation patterns offshore from Chicago are southerly due to the counter-clockwise rotation, but near shore they are again northward, as they were with the winter circulation under the same wind conditions. Thus, about 65 percent of the time, the flow pattern in this region of the lake is similar near the surface to what is depicted here.

Not quite as much detail can be obtained from the current meters stationed at lower depths, because there were a smaller number of stations from which to obtain data.

The next slide, figure 6-9, shows the circulation pattern obtained from current meters at a depth of 90 meters. This not only demonstrates the presence of the two ridges extending northeast from the area around Milwaukee, dividing the lake into two basins, but demonstrates also

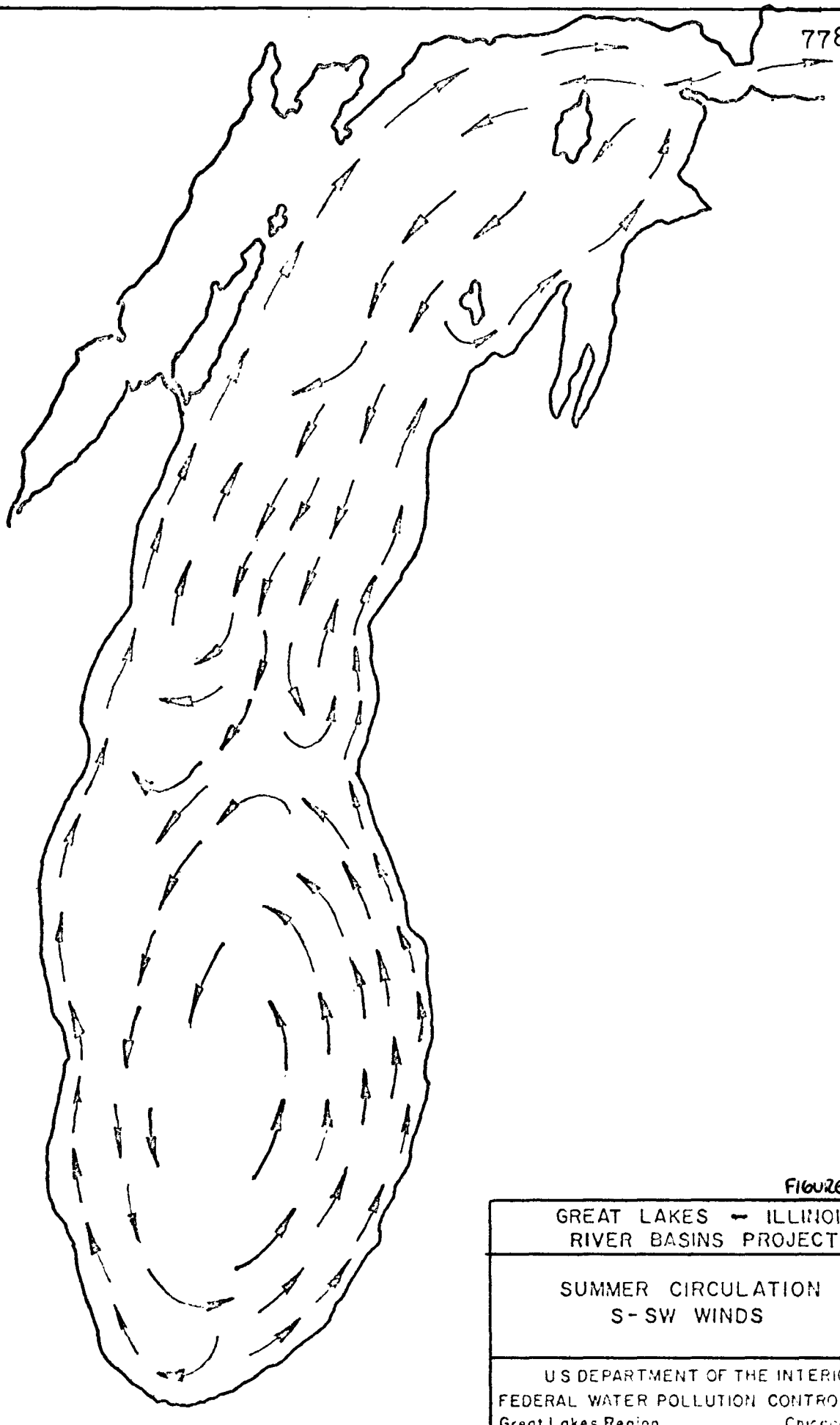
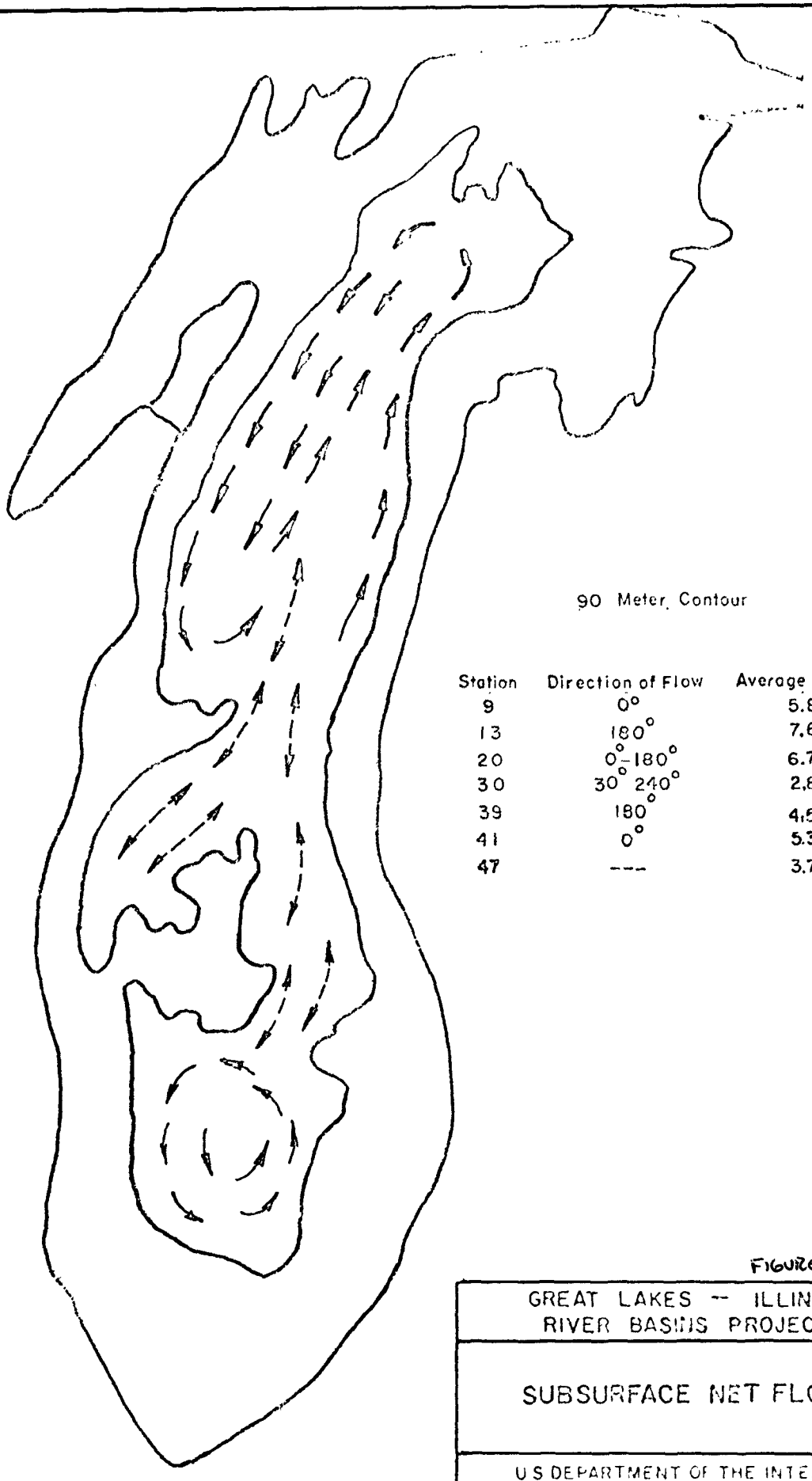


FIGURE 6-7

GREAT LAKES – ILLINOIS
RIVER BASINS PROJECT

SUMMER CIRCULATION
S-SW WINDS

U S DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN
Great Lakes Region Chicago, Illinois



90 Meter Contour

Station	Direction of Flow	Average Speed
9	0°	5.8
13	180°	7.6
20	0°-180°	6.7
30	30° 240°	2.8
39	180°	4.5
41	0°	5.3
47	---	3.7

FIGURE 6-9

GREAT LAKES -- ILLINOIS RIVER BASINS PROJECT

SUBSURFACE NET FLOWS

U S DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN
Great Lakes Region Chicago, Illinois

the presence of a great area of variable flow, yet maintaining a generalized counter-clockwise rotation. The variability observed in the currents at depth is considerable and appears to be due largely to the existence of the thermocline and internal wave patterns which exist there, especially in the summertime.

One of the most significant contributions to the scientific understanding of currents in Lake Michigan was the collection and analysis of the temperature data obtained from the recording stations in the lake, and from a large number of intensive sampling cruises conducted to other parts of the lake. With these data it was possible for the investigators to establish the shape of the thermocline at different times of the year and to observe the variation in temperature caused by the wave-like disturbances existing at any one location. A short time before these data were available, Dr. C. H. Mortimer at the University of Wisconsin had analyzed temperature records from the water works intakes around the lake and had predicted that this type of pattern

would exist. He also presented a theoretical explanation for this situation.[2]

Upon examination of the current data in conjunction with the theoretical models postulated for the type of flow, it was possible to confirm the existence of current patterns which are specifically related to a two-layer system dominated by wave forms. One of the most remarkable features is that water below the thermocline is moving in a direction almost exactly opposite the direction of water in the layer above the thermocline.

The extensive temperature data also established the existence of density barriers which are effective in separating nearshore regions of the lake from the main body of water, primarily at the end of winter. For lack of a better term, perhaps, this boundary is called a thermal bar. On the shore side of this thermal

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2/ "Frontiers in Physical Limnology With Particular Reference to Long Waves in Rotating Basins", by C. H. Mortimer, Publ. No. 10, Great Lakes Research Division, University of Michigan, 1963, pp. 9-42.

bar, the currents are generally influenced by the shore configuration and not as much by the motions in the main body of the lake, especially those due to the wave conditions on the thermocline.

The wind data obtained from the buoys at the various locations in the lake and from those on the shore were related to the surface currents, and it was demonstrated that the current responded within a short period of time, say an hour or so, to changes in the wind speed and direction, as would be expected from the theoretical considerations.

As a final note in the specific observations which have been made regarding Lake Michigan, one cannot overlook the results obtained by earlier investigators who released drift bottles into the lake to determine where they were carried by the current. These studies showed a great deal of variability, but at the same time showed that effective transport from one side of the lake to the other could result. This, no doubt, could be substantiated by thousands of people living around the lake who

have observed the transport of ice and floating pollutants, specifically oil or dead fish, over wide expanses of the lake surface.

TRANSPORT OF POLLUTANTS

Our main concern with the study of currents in Lake Michigan is the determination of the fate of pollutants finding their way into the lake. There are a number of ways wastes can be classified, but for the discussion here, it will be necessary only to divide the pollutants into two classes--soluble and non-soluble. Soluble pollutants are fluid-bound properties and, as such, are moved from place to place just as the water is moved--thus our interest in currents, which describe the direction and speed of water movement. The fate of non-soluble pollutants, however, is more difficult of analysis. In this category we would consider oils or other liquids which do not intimately mix with the water, as well as solids of all sizes, either fine-grained clays, cabbages, or car frames. Some of these may be small enough or light enough to be moved around with the water

almost indefinitely, but frequently they suffer the actions of gravity and rise to the surface or settle to the bottom. We must, therefore, analyze what happens to both types of pollutants when they're discharged to Lake Michigan waters.

Waste discharges are frequently made in the nearshore waters, either through outfall devices especially designed to distribute the material over wide areas, or simply through pipes terminating near the shore. In the latter case especially, the fate depends upon the local conditions and cannot be predicted from the general circulation patterns described in the Lake Currents Report. If the pollutional material is deposited within some manmade obstruction, as a harbor, or behind a natural barrier such as a thermal bar, it will eventually be released and mixed with the main circulation pattern. Solid material may accumulate on the bottom, or the currents may be large enough to distribute the material over long distances downstream. If the localized buildup of pollutional material is caused by a combination of natural phenomena, such as the thermal bar

or a period of very calm weather, it can be expected to change rapidly and frequently, whereas the localized buildup in a harbor or behind a breakwater would be more permanent. Some materials experience a decay in their pollutional strength, so that when finally mixed with the main flow in the body of water, the concentration is less than if they were initially discharged to the main flow. In the long run, the result with respect to a body of water the size of Lake Michigan is exactly the same. What is more important is that many wastes contain a fraction which is not degradable and has a tendency to build up indefinitely in the system unless carried out by the discharge waters. Phosphorus is an example of a substance found in waste material which exhibits this behavior.

Once introduced into the main flow, pollutants will move around the lake more readily, and for periods of time as short as several days, may appear to be traveling in a rather steady direction. This type of motion may be inferred from the first slides

showing the general circulation patterns. However, this was meant to convey the idea of a long-term average, at least several days, and the actual motion observed at a particular location was by no means as smooth as that throughout the period. Because of oscillatory wave patterns and other physical phenomena affecting the surface motion, a parcel of water would move around considerably within the distance actually traversed. This was demonstrated with the data obtained from the surface current meters for all these stations, an example of which is shown in the next slide, Figure 7. According to this analysis, in a period of several days a particle would have traveled from the starting point to the end of the last arrowhead, but in so doing would have traveled a complex path along all the arrows before reaching its final position. This behavior might be expected from an object which was floating on the surface, or possibly even an oil slick. However, soluble pollutants would be subjected to additional random motions on a smaller scale superimposed on this type

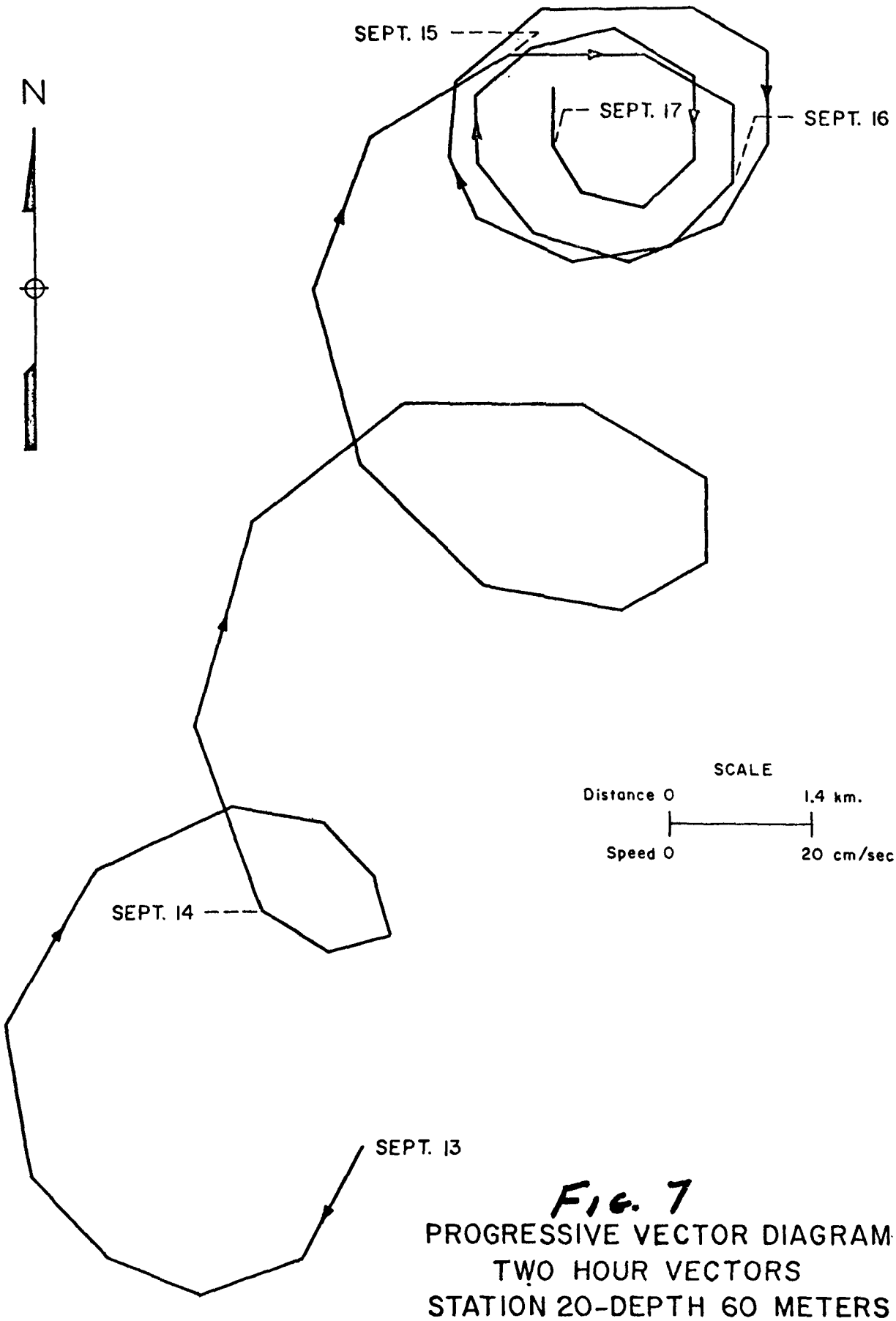
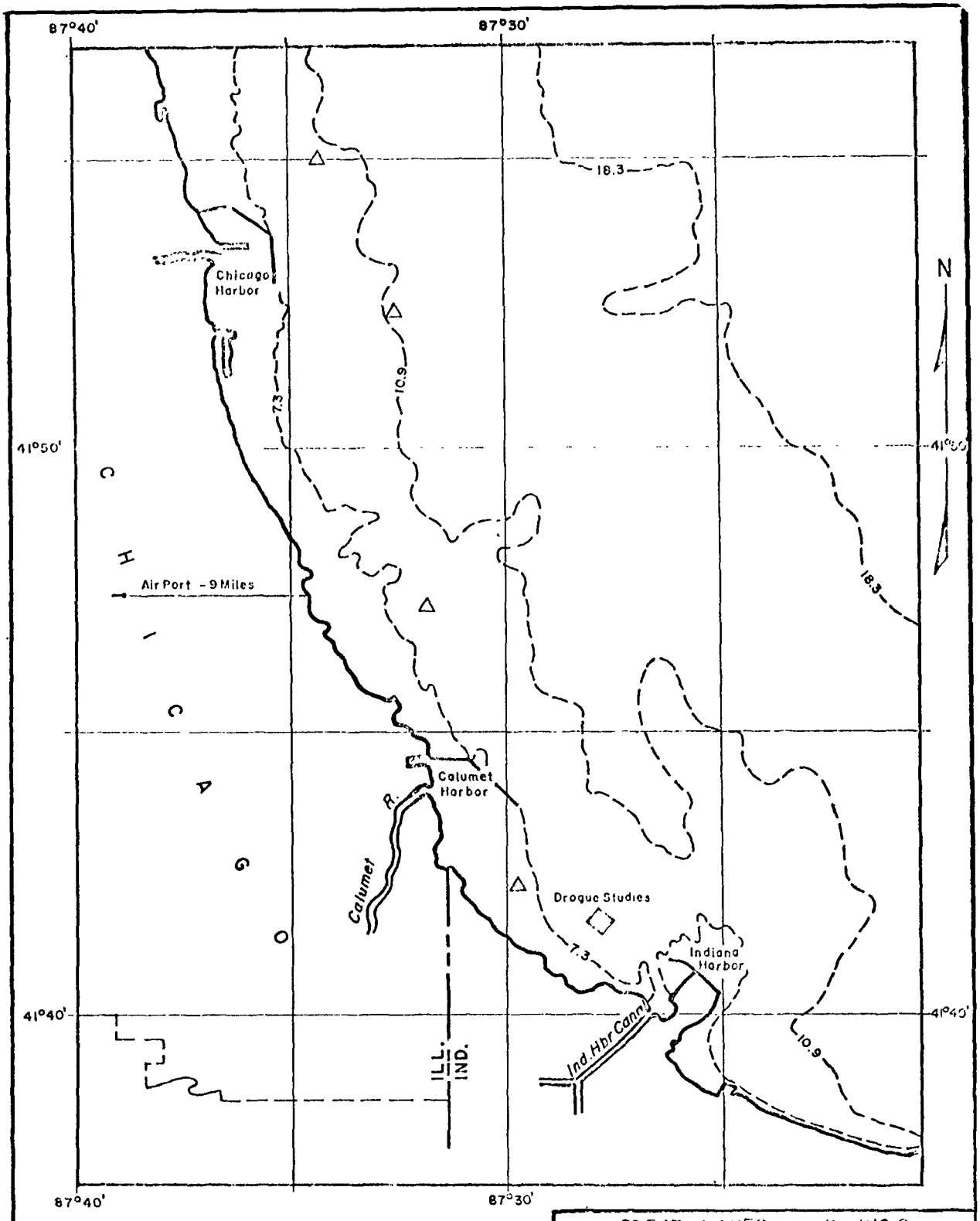


FIG. 7
PROGRESSIVE VECTOR DIAGRAM
TWO HOUR VECTORS
STATION 20-DEPTH 60 METERS

of motion. This is related to the turbulent mixing among and within water masses as they are moved along by variable currents. Evidence of this was presented by the drogue studies conducted by the technical staff. The location chosen for these studies was approximately a mile and a half offshore near Indiana Harbor as shown in Figure 8-4.

In addition to showing how pollutants move along with the main current in the area, they provide information on the rate at which material is spread out or dispersed due to turbulence. In two tests conducted on successive days, dispersion was observed similar to that found by other investigators in the Great Lakes and other bodies of water. On one day, drogues were simultaneously released at a depth of 1-1/2 meters and also at 6 meters. During that test, the wind was essentially uniform from the southwest and the drogues near the surface traveled eastward under this influence. As shown in the next slide, Figure 8-16--I will again mention that the wind is indicated in the bottom half of the slide and

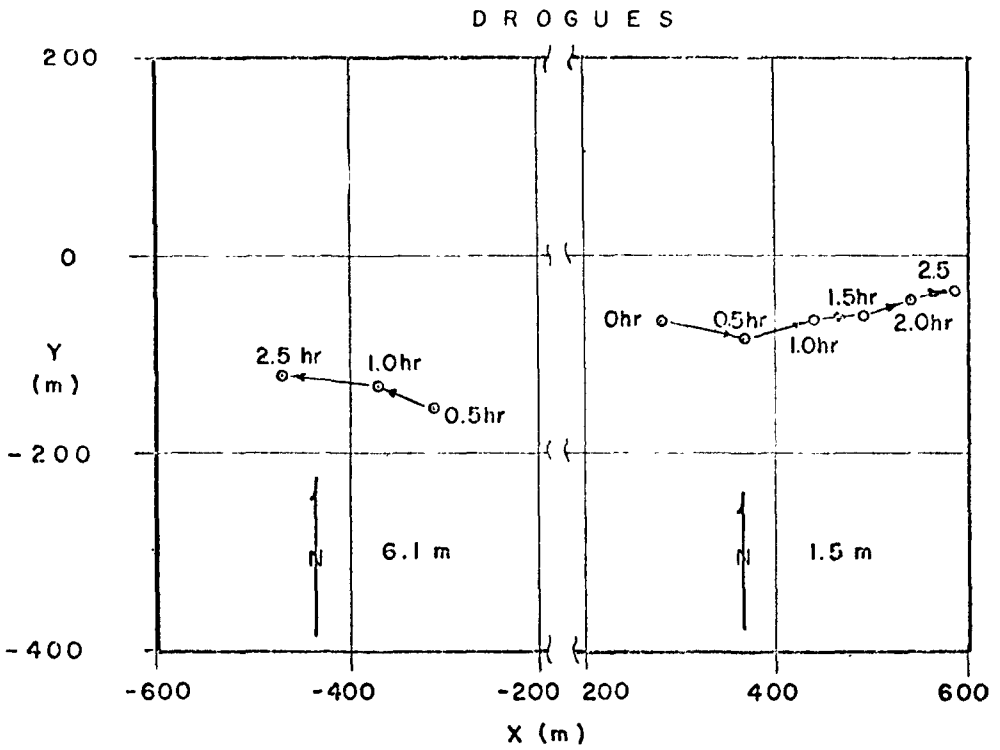


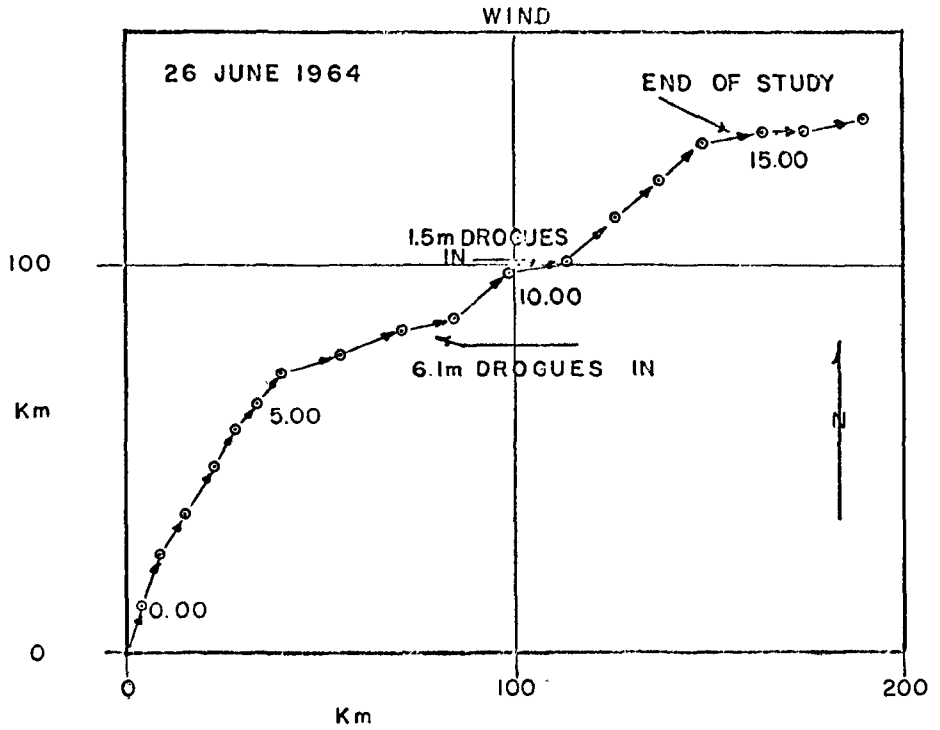
GREAT LAKES — ILLINOIS RIVER BASINS PROJECT

MAP OF STUDIED AREA FOR RUNS 1 & 2

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Great Lakes Region — Chicago, Illinois

FIGURE 8-9





GREAT LAKES - ILLINOIS RIVER BASINS PROJECT

MOVEMENT OF DROGUES & WIND TRACK RUN 2

US DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN
Great Lakes Region Chicago, Illinois

FIGURE 8-16

the wind pattern is to the northeast; the surface drogues are shown in the right half of the upper figure; they move eastward--the drogues at six meters, however, moved in almost exactly the opposite direction. This rather unexpected behavior further demonstrates the complexity of the current system and the highly variable nature of the transport of pollutional material discharged into the lake. Any soluble material would be expected to move along as did the surface drogues, spreading out as the group moved to the eastward, while particulate matter in the waste plume, if it settled out at all, would soon reach the level where it would begin to be carried in the opposite direction. Also, if the soluble material were mixed to that depth, it too would begin to move back toward the source and to the west.

That is the end of the slides.

As the last step in this consideration, you might imagine this type of flow superimposed upon the flow described by the theoretical particle moving along as I showed two slides

ago. If a very strong thermocline exists, as it usually does in the summer in Lake Michigan, the soluble pollutants will continue to be mixed and carried along in the upper layers, whereas the particulate matter will be expected to settle through the thermocline and be influenced by the flow in the lower levels of the lake, eventually with the high likelihood of settling to the bottom. On the bottom they may decompose or react in a way that contributes to poor water quality in an area for a long period of time. In many large bodies of water, this takes place to the extent that water quality is the least desirable in the lower levels of the lake.

Because of the barrier presented by the thermocline, this material is not mixed with the surface waters and is frequently not carried out of the lake during the summer. In the fall, when the surface layers cool and the density begins to increase, a point is reached where the density is nearly uniform throughout, and wind can cause the lake contents to mix more fully, especially from top to bottom.

This overturning of the water then allows the poor water quality which has been established during the summer to become evident.

If, for example, materials at the bottom had been contributing to the buildup of phosphorus in the overlying waters, then in the fall the phosphorus content would be mixed with the surface waters, which may allow for subsequent growth of algae. The same physical characteristics can exist in the springtime, although usually to a lesser extent, but more importantly, at a time when the summer is beginning and algae are stimulated to grow more than they would be in the winter. This may allow for a long-term cycling of algal growth in the summer due to an accumulation of phosphorus-bearing compounds deposited on the bottom of the lake over long periods of time.

Scientists have always been interested in determining how long it would take for a body of water as large as Lake Michigan to reach a given level of pollution based on the level of waste inputs. To do this, it is always necessary

to assume that the lake is a much simpler hydrodynamic system than it really is. The same sort of analysis, in reverse, applies to estimate how long it would take for the lake to free itself of pollutants.

R. H. Rainey at Oak Ridge National Laboratory performed such a computation for Lake Michigan a short time ago.[3] He assumed that the lake was uniformly and completely mixed at all times, and that all the freshwater flow into the lake was effectively put in at the southern end of the lake so that there would be continuous and positive flushing action out of the Straits of Mackinac. He also assumed that when the problem was recognized and the pollution control measures were put in, they would be 100 percent effective, and with these assumptions, he calculated that it would take about 100 years to reduce the pollutional concentration in the lake by 90 percent.

This estimate is exceedingly low,

3/ "Natural Displacement of Pollution from the Great Lakes", Robert H. Rainey, Science 155, pp. 1242-1243, March 10, 1967.

because his assumptions do not fit the actual situation which exists in the lake. First of all, not all freshwater flow enters the southern end of the lake--it is distributed around the lake and fully one-fourth of the annual flow originates in the Green Bay area.

Secondly, the concentration of pollutants is not uniformly distributed at all times. During the summer the lake is stratified to the extent that there is very little interchange of water or pollutional material from the lower levels to the surface levels. Independently of season, pollutional material is not uniformly distributed because of the barriers caused by manmade and natural obstructions near the coastline.

Finally, it is unrealistic to expect that pollution control measures would be 100 percent effective. There will always be some residual inflow of pollutional material.

Thus, if one were to incorporate these features into a flushing model of Lake Michigan it would not be surprising to come up with a time more nearly on the order of 1,000 years.

DR. DONALD J. BAUMGARTNER

SUMMARY

I would like to recall four things in summarizing my remarks.

First, theoretical considerations of the motion of water in large basins suggest that the flow patterns will be very complex, but interrelated, being influenced by many physical factors of our environment, as well as man's attempts to modify the environment. The variability of these factors in time and space suggests further that the contents of large bodies of water will be mixed, also to a variable extent.

Second, specific studies conducted on Lake Michigan and on portions of the other Great Lakes demonstrate that the currents observed have been in accord with the theoretical consideration. They vary in direction and magnitude from surface to depth, from length to width, and from side to side. The variability in time is significant on a seasonal basis, but important varabilities are also observed in shorter periods of time,

such as days and even hours. Superimposed on the hourly variation is a continuous process of turbulent mixing of small parcels of water.

Third, the fate of pollutional materials discharged to Lake Michigan is determined initially by localized considerations: shallow water near the shore, shoreline configuration, the presence or existence of manmade barriers, the variable existence in time of phenomenological barriers, such as thermal bars, and the near-shore wind. Eventually the material is intermingled with the more general circulation patterns of the main body of water. Here again the fate is influenced by the variability of the thermocline and weather conditions. Pollutants which tend to float or sink will be subjected to different rates of mixing and retention than will completely dissolved substances. The variability in currents and the existence of turbulence conducive to diffusion indicate that pollutional material will not travel in patterns which remain discrete for very long periods of time, but will contaminate adjacent regions of water, and eventually their presence

will be manifested in all parts of the lake. Because some fractions of the waste are persistent, natural decay of pollutant material in time cannot be relied upon to prevent the degradation of water quality.

Fourth, it is frequently the case that our scientific ability to monitor subtle and long-term changes in water quality does not allow us to determine when critical conditions are going to occur. If concentrations of pollutants are allowed to increase, as they are in Lake Michigan, to the point that a serious water use problem occurs, it will take a very long time under the best of conditions to reduce their concentrations to acceptable levels. Dr. Bartsch's testimony shows that over 14 million pounds of phosphates are discharged to Lake Michigan every year, but only 800,000 pounds are removed per year, indicating that they are obviously building up in the lake. Every year that this practice is continued is likely to add tens of years to the time required for the lake to be restored.

MR. STEIN: Thank you, Dr. Baumgartner.

DR. DONALD J. BAUMGARTNER

Are there any comments or questions?

Mr. Mitchell.

MR. MITCHELL: Doctor, in reading your summary, and the question also was asked of your predecessor on the platform, would you feel that because of the tremendous time that it is going to take to restore the lake, if we let it become too high a concentration of nutrients, that the nutrient problem is the number one priority for the conferees to consider here today?

DR. BAUMGARTNER: I don't claim any special knowledge in that area, but from what I have read of this problem compared to other problems I think it is certainly one of the most important.

MR. STEIN: Any further comments or questions?

Mr. Poston.

MR. POSTON: I think, Dr. Baumgartner, you have indicated or Dr. Bartsch has indicated that we had nutrients coming in from remote parts of the Lake Michigan Basin from communities that were as much as 50 to 100 miles

away, and they come in through the rivers and then these materials reach the lake. Would you say then that these become intermingled with all of the water of the lake in the course of time?

DR. BAUMGARTNER: Yes, that is a true statement as far as I am concerned.

MR. POSTON: Well, Mr. Chairman, I think this was one of the points that we wished to make.

MR. STEIN: Let me see if I can restate this.

Phosphates are a critical material. As I understand your statement, the notion is that if a relatively long-life pollutant or long-life material like phosphate, which is going through a cycle, gets into the lake from any source, from your analysis of current studies it is likely through a period of time to be found in almost any portion of the lake?

DR. BAUMGARTNER: Yes, that is true.

MR. STEIN: And it is likely to remain there a very, very long time?

DR. BAUMGARTNER: That is correct.

My estimate of approximately 1,000 years to remove 90 percent of any material like that is still based on a rather simple situation.

MR. STEIN: This is, I feel, the essence of the interstate aspect of the case, and the point that Dr. Bartsch mentioned on the effect of the phosphates and on these current studies--that anyone bordering on the lake is not an island unto himself. You have to expect that you are all contributing to each other's pollution problem, and the four States and I hope the Federal Government with you will have to work together in working out this problem.

The point is once they get into the lake and into the cycle or the nutrients get into the lake, we are going to have a very difficult time and a really, really long time in trying to get rid of them.

MR. HOLMER: Mr. Stein.

MR. STEIN: Yes.

MR. HOLMER: This is a very important point, and I am curious whether there is sufficient information on which to demonstrate

what happens to one of these pollutants which originates, in one of our cases, 125 miles from Green Bay, which is, of course, an arm, not the whole of Lake Michigan, although we will certainly concede the fact that these do mix. I wonder if we know enough about what happens to phosphates? I realize that Dr. Baumgartner is not the right man to ask the question of.

MR. STEIN: He may well be.

MR. HOLMER: Well. But do we know enough about what happens to a phosphate between its discharge into a stream and its arrival at the outlet into the lake to warrant considerations of treatment?

MR. STEIN: Yes. Well, if Dr. Bartsch is here, or Dr. Baumgartner, perhaps, can answer it. Let's see the way I understand it; I thought I understood.

Will you come up, Dr. Bartsch?

I thought I understood this, but let me see if I am correct.

Why don't you stay up there, Dr. Baumgartner, with him.

DR. DONALD J. BAUMGARTNER

The way I understood this is that you have a cycle of nutrients in the lake. Once the phosphates get in the lake, they are going to remain in there; they may get into algae, they may get into fish, they may die, but they are always going to be there in self-contained form, one form or the other. I am trying to state this as I understand it.

The next point is that from the current studies, once anything gets in there from a particular point it is going to remain in the cycle of the lake, likely to show up at any point in the lake, and may remain there as long as 1,000 years.

This is what I understand from these two gentlemen is the theory of the case.

Would you come up, either one of you, and try to elucidate on that?

DR. BARTSCH: I think, Mr. Holmer, the first thing I would say is that, yes, certainly we do not know all of the things we would like to know about phosphorus. At the same time, there are many things we do know about phosphorus and about the dynamics

of movement of phosphorus.

And I would say in reference to your first question, or what I take to be your first question, which I think has reference to the Fox River--and incidentally, my home town is Kaukauna, and so I know something about the Fox River and also about the lake.

I think in my mind there would be no question, based upon what we know about phosphorus, that phosphorus that comes out of Lake Winnebago, whether it is in the form of solution or whether it is in the form of Mycrocystis or Gloeotrichia or the names of any of the other algae which are a real problem because they pass down the Fox River and compete with other organic wastes for the assimilation capacity there, eventually end up in Green Bay except for those parts that drop off to the bottom along the way.

I think that the fact that there is planktonic bluegreen algal problem in Green Bay is a reflection of the fact that you are having phosphorus as well as other nutrients coming off the watershed of the Fox

River reaching Green Bay. If this were not the case, I think you would not have that kind of problem there.

If we could theorize as to what happens to a particle of phosphorus once it reaches Green Bay, some of it is in solution, part of it is already incorporated into the bodies of algal cells, some of it is incorporated into other kinds of organisms, both plant and animal, and these organisms in the natural processes of production and decay are picking up phosphorus and releasing it back again into the water. This process goes on free in the water, and so this means that phosphorus which is released in this fashion to the water is passing along wherever the water goes.

At the same time, some of these organisms, as they die and settle to the bottom, become incorporated into the bottom depths. Well, this simply complicates the picture, because again we don't know everything we would like to know about the interchange of phosphorus between these bottom sediments and the overlying waters, and this is one of

the areas in which we are putting a considerable part of our research resource at the moment. But we do know that with the kinds of conditions you have in the bottom in Green Bay, namely low dissolved oxygen for one thing, you have a real climate there for the release of phosphorus into the overlying water so that it could be carried along and go out through the strait at Sturgeon Bay or out around the tip of the peninsula and certainly in some concentration or quantity, at least, find its way into the general circulation of Lake Michigan.

MR. HOLMER: If I might.

MR. STEIN: Go ahead.

MR. HOLMER: I would like to just pursue this a little bit further.

The particular case in point that attracts our attention is Portage, for example, which is above Lake Winnebago; and if phosphorus gets into Lake Winnebago from the upper upper Fox and is in Lake Winnebago, it presumably stays there for a rather substantial period of time.

The question we would face somewhere

along the way is whether treatment at Portage is critical enough to the welfare and health of Lake Michigan to warrant attention to the phosphorus problem that far away from the lake.

DR. BARTSCH: Well, to be completely honest, and I intend to be completely honest, it seems to me that one would first pick up--if your resources for remedial action are limited--you would first pick up the most pressing and the most critical problems. If this is logical, then I would start at some downstream points and work upstream.

You are complicated here in your challenge because of Lake Winnebago, in the first place, and the fact that Lake Winnebago is serving in part as a sump for the capture for some of these nutrients. If this were the only aspect of it, I would say let's don't worry about Portage, for example. But I think we have to realize that what you have happening at the mouth of the Fox River at Green Bay is a reflection of all the things that are happening in the watershed, and it seems to me that if we are ever going to cut off the

input of nutrients into Lake Michigan effectively and adequately, we have a real tough problem. We not only have to cut it off at the source in the form of wastes, but I think we have to consider whether there is anything in our technology now that indicates to us that we can do something about Lake Winnebago to bring it back, if we are ever going to bring Lake Winnebago back. But then I think this doubly emphasizes the importance of Portage.

I am not sure that this is a succinct answer, but I think it is at least something to think about.

MR. STEIN: Do you have anything further?

MR. HOLMER: I have another question for Dr. Baumgartner.

MR. STEIN: Doctor, would you come up, please?

MR. HOLMER: In connection with the matter of lake currents and their influence on pollution, is it conceivable that any withdrawal that man might make from Lake Michigan and diversion of that water to any other place

might so affect the currents of Lake Michigan as to cause any kind of pollution problem or manmade involvements with respect to these currents virtually negligible?

DR. BAUMGARTNER: I think they are not negligible in the actual location where the withdrawal might be made. Again I think the local conditions would determine what kind of problems are associated with this. And this would require some special studies.

However, if the diversion ever got to the point where it exceeded the amount of flow available for discharge from the lake, the 40,000 or 50,000 cfs, this could only mean that there would be no net outflow from the lake except what occurs by mixing with Lake Huron, and also the lake levels would have to decrease. This would mean there would be less water available and in the long run you would be approaching a much smaller lake divided into more and more two basins. This would obviously have some long-term effect on current patterns and the pollutional quality of both sections of water.

DR. DONALD J. BAUMGARTNER

MR. STEIN: Are there any further comments or questions?

You know, I would like to call attention to one thing with Dr. Baumgartner up there, something that occurred to me. Some of you think that it might be wise to wait until Mr. Klassen, Mr. Poole, Mr. Oeming or myself retire, we have a kind of an institutional operation going on. This is why I am intrigued with Dr. Baumgartner. The predecessor of Mr. Oeming was Milton P. Adams, and I think I and most of the people here may have learned the business from him. I see Alice Coughlin there, who is the Secretary to the President of the Water Pollution Advisory Board, who knew me when I came out of law school. And of course I grew up in the business with Dr. Bartsch who testified here.

But Dr. Baumgartner is a new generation. I knew him when he came right out of engineering school. And as you see, he has been trained in a phase of this problem that none of us knew when he got out of school, that is ocean-ography and currents, because we have to get

more sophisticated all the time.

So I expect we will be going on and on, and I think the hope of this program and the future rests with the experts, such as Don Baumgartner who has done such a wonderful job here.

Thank you very much.

Mr. Poston.

MR. POSTON: Next we would like to hear from Dr. Leon Weinberger, who is our Assistant Commissioner in the Federal Water Pollution Control Administration out of Washington. He is head of our overall research program.

Dr. Weinberger.

DR. LEON W. WEINBERGER

STATEMENT BY DR. LEON W. WEINBERGER
ASSISTANT COMMISSIONER, RESEARCH AND DEVELOPMENT
FWPCA, WASHINGTON, D. C.

DR. WEINBERGER: Mr. Chairman, conferees.

I have a prepared statement. With your permission, I would like to have that introduced in the record and I will attempt to abstract and perhaps add some supplemental comments as we go along.

MR. STEIN: Without objection, that will be entered into the record as if read.

(Which said statement, with attachments and appendices, is as follows:)

STATEMENT OF DR. LEON W. WEINBERGER
ASSISTANT COMMISSIONER, RESEARCH AND DEVELOPMENT
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
U. S. DEPARTMENT OF THE INTERIOR
at the
LAKE MICHIGAN ENFORCEMENT CONFERENCE
February 1, 1968

DR. LEON W. WEINBERGER

WASTE TREATMENT FOR PHOSPHORUS REMOVEL

Wastewater treatment facilities can be designed, built and operated to remove at least 80 percent of the phosphorus found in municipal wastewaters. Using available technology and through laboratory, pilot plant, and full-scale plant data reported in the open literature (see list of references), design and consulting engineers can design treatment facilities with a high degree of reliability in projected cost and performance. Equipment is being designed and sold which will achieve at least 80 percent removal. The 80 percent figure is conservative--the evidence indicates that 90 to 95 percent, and even more, phosphorus can be removed effectively.

Any confusion as to the efficacy of phosphorus removal probably stems from the fact that many methods have been put forth and are under study.

A. Chemical Processes:

1. Lime

2. Alum-lime

DR. LEON W. WEINBERGER

3. Alum

4. Iron.

B. Biological Processes

1. Activated sludge

2. Algae

C. Biological-Chemical Processes

1. Activated sludge-chemical

2. Algae-chemical

D. Other Processes

1. Ion exchange

2. Electrodialysis

3. Effluent spraying on land

4. Reverse osmosis

5. Electrochemical

6. Distillation

A summary of efficiencies for various treatment processes is presented in Table 1.

The treatment process which can be designed, constructed, and operated with greatest confidence today for phosphorus removal would employ chemical treatment. A typical flow diagram is shown in Figure 1. Certain types of combined chemical-biological treatment systems will also be ready for application soon. These

TABLE 1. PHOSPHATE REMOVAL EFFICIENCIES OF VARIOUS TREATMENT PROCESSES
(Maximum achievable efficiencies unless the range is indicated.)

Treatment Process	Total[1] Phosphorus Removal (%)	Scale of Operation	Reference
Biological Processes	47.1(PO_4)[2]	Full	Wirtz (1966)
Activated sludge	--	Lab	Culp and Slechta (1966)
	--	Lab	Ludzack and Ettinger (1962)
	80 (ortho PO_4)	Lab	Levin and Shapiro (1965)
	10-30 (ortho PO_4)	Full	Levin and Shapiro (1965)
	25-38 (ortho PO_4)	Lab	Feng (1962)
	37-77 (PO_4)	Full	Hurwitz et al. (1965)
	--	Full	Johnson (1968)
	--	Lab	Johnson and Schroepfer (1964)
Algae	70	Lab	Gates and Borchardt (1964)
	41.3	Full	Rand and Nemerow (1964)
	44.4-95[3]	Lab	Rand and Nemerow (1965)
	85(PO_4)[4]	Lab	Fitzergerald & Rohlich (1964)
	100[5]	Pilot	van Vuuren et al. (1965)
	90	Lab	Bogan (1961)
Biological-Chemical Processes			
Activated sludge--chemical	95(approx.)[6]	Lab	Tenney and Stumm (1965)
	74-98	Pilot	Barth and Ettinger (1967)
	80-85 (Primary stage only)	Lab	Dorr-Oliver,Inc. (1967)
	87-99	Pilot	Eberhardt and Nesbitt (1967)
Chemical (lime)--algae	97 (approx.)	Lab	Sawyer and Buzzell (1962)
	80-90	Lab	Buzzel and Sawyer (1967)
Chemical Processes			
Lime	93.5(PO_4)	Lab	Rand and Nemerow (1965)
	99	Lab	Lea et al. (1954)
	77.7-90.7[8]	Lab	Sawyer and Buzzell (1962)
	92-100 (PO_4)	Lab-Pilot	Bishop et al. (1965)
Alum-lime	95	Lab	Lea et al. (1954)
Alum	97	Lab	Rand and Nemerow (1965)
	94	Lab-Pilot	Lea et al. (1954)
	99 (Sol.PO_4)	Lab	Rohlich (1961)
	96-100 (PO_4)	Lab-Pilot	Bishop et al. (1965)
Iron	99 (Sol.PO_4)[9]	Lab	Rohlich (1961)

(continued)

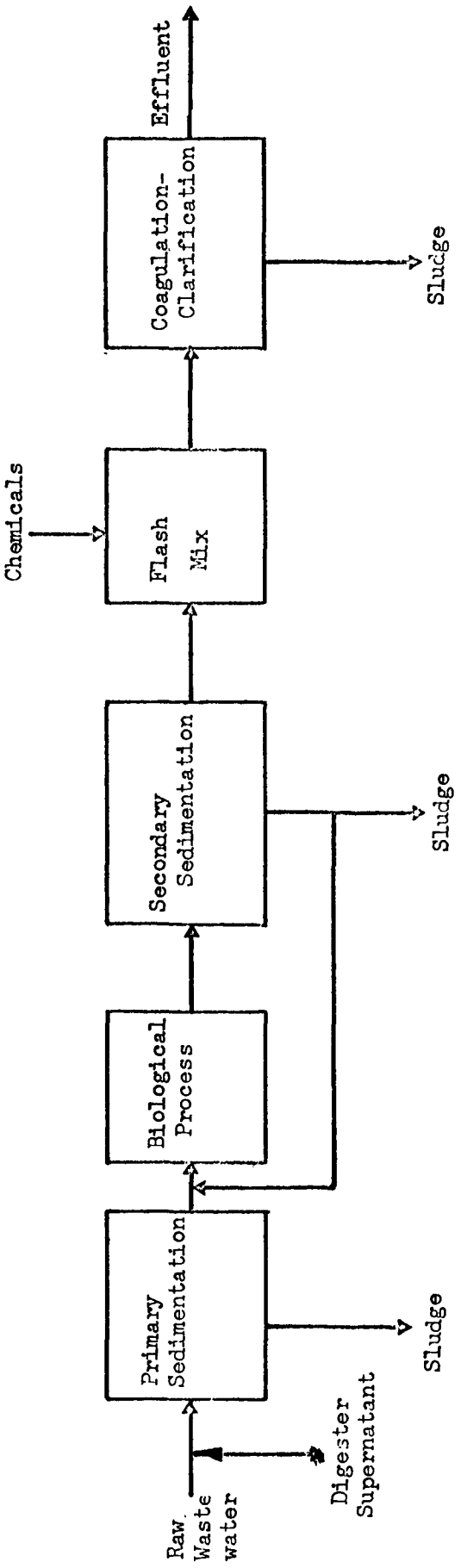
Treatment Process	Total[1/] Phosphorus Removal (%)	Scale of Operation	Reference
Other Processes			
Ion exchange	98.5-99.6	Lab	Rand and Nemerow (1965)
	95	Lab-Pilot	Eliassen et al. (1965)
	--	Lab	Culp and Slechta (1966)
Electrodialysis	50(PO_4)	Lab-Pilot	Stephan (1965)
Effluent spraying	29[11]	Pilot Plant	Brunner (1967)
Effluent spraying on land[12]	76-93	Full	Foster and Ward (1965

1 Except where indicated
2 Average of monthly averages, December 1965 and February 1966
3 Cultivation time from 4 to 37 days
4 pH dependence reported
5 Flocculation and algae flotation
6 At optimum alum-polyelectrolyte dose
7 At optimum dosage and pH conditions
8 On raw sewage
9 Ferrous or ferric sulfate
10 In conjunction with pre-treatment or synthetic feed
11 Based on treatment for 40 percent demineralization
12 Dependent on soil loading and climatological conditions

Figure 1

Phosphorus Removal Processes

Chemical Treatment



processes are illustrated in Figure 2.

Chemical treatment (Figure 1) may be applied as a tertiary treatment or independently as a separate treatment for various wastewaters. Chemical treatment may also be used to eliminate or reduce the recycle of phosphorus from digester supernatants or from thickener liquids.

The two common types of chemical treatment for phosphorus removal are: -(1) Alkaline removal with lime, and (2) Adsorption or precipitation with metallic hydroxides.

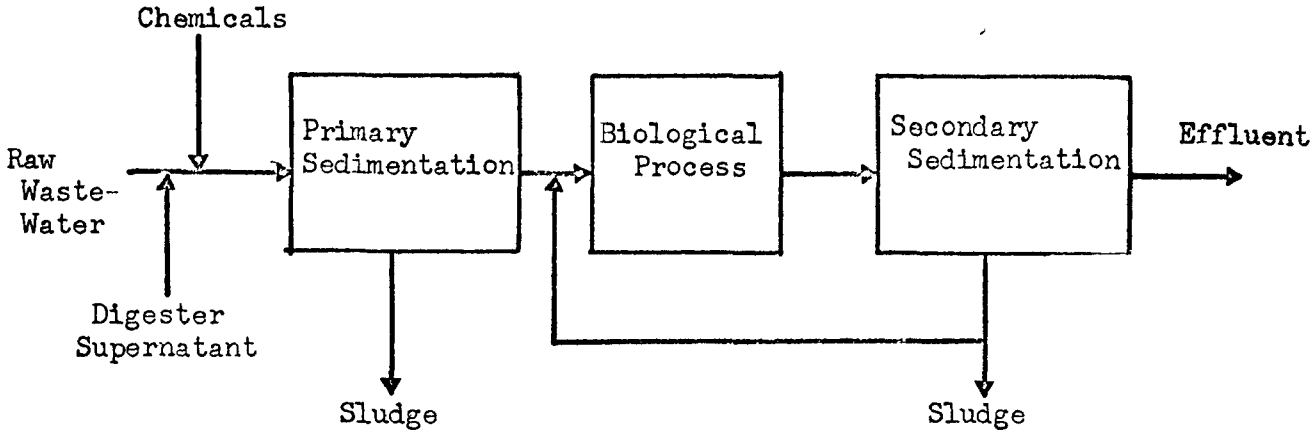
Typical phosphorus removals for either type or combination of chemical treatments readily exceed 90 percent. The principal advantage in chemical treatment lies in the close control that can be maintained in actual plant operation. Another advantage is that laboratory data will predict dosage levels for particular phosphate residuals as well as settling rates for clarifier designs. It should be noted that in addition to phosphorus removal, chemical treatment will also result in significant reduction in organic and inorganic turbidity, reduction in BOD and COD, and reduction

Figure 2

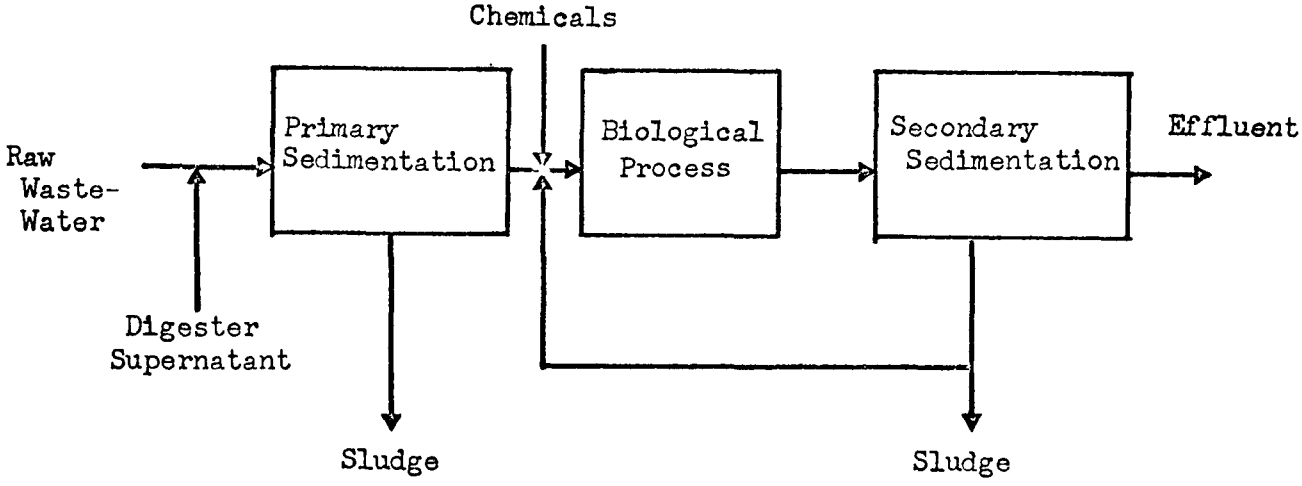
Phosphorus Removal Processes

Chemical - Biological Treatment

(a) Chemical Addition in Primary Stage



(b) Chemical Addition in the Biological Stage



in bacterial numbers. Chemical treatment can be effective even with fluctuations in the preceding conventional processes and should maintain a more uniform effluent quality than other phosphorus removal processes. Appendix A contains descriptions of plants which have successfully utilized chemical phosphate removal.

Chemical-biological treatment may be illustrated by Figure 2. Process 2(a) involves the addition of a precipitant to accomplish most of the phosphorus removal in the primary tank with additional removal of phosphorus in the biological phase. A recent study (Buzzell and Sawyer) shows that lime treatment of raw wastewater can remove 80- to 90 percent of influent total phosphorus. Laboratory data by Albertson and Sherwood indicate that even more economical benefits are achieved when solids are recycled around the primary treatment unit. Advantages in this approach include improved clarification and BOD removal in addition to improved phosphate removal. Lime recovery may be used to reduce costs even further. Several new plants destined to utilize these processes have been

designed, e. g. Rochester, New York.

Process 2(b) involves the addition of minerals directly into the aeration tank resulting in the formation and precipitation of slightly soluble phosphorus compounds. Additives such as aluminium or iron salts cause no interference in the biological activity, and the mixing and residence times provided by the aerator allow sufficient time for formation of precipitates. There has been no increase in the volume of the sludge produced because of improvement of the settling characteristics of the mixed liquors. This latter process has been referred to Barth and Ettinger as "mineral addition."

FWPCA has completed a field study of the mineral addition process at the Xenia, Ohio, wastewater treatment plant. The data show that the plant normally removes about 20 percent of the influent phosphorus. With the addition of sodium aluminate in the ratio of Al/P of 1.8:1, removals of 85 to 92 percent were obtained. The plant returned to the normal 20 percent removal at the completion of the run

when the aluminate addition was stopped. The chemical cost of phosphorus removal was five cents per thousand gallons ($50 per million gallons). Considering that this was a field investigation, using makeshift equipment, the results show promise when this approach is applied in a more controlled situation.

The table given in Appendix B presents a status summary of various operational projects in the United States designed for phosphate removal utilizing biological, chemical, or chemical-biological means. The Federal Water Pollution Control Administration has actively participated in demonstrating phosphorus removal treatment systems through research and development grant funds. These projects are presented in Appendix C.

Current operational experience indicates that tertiary chemical treatment costs will be affected by local factors such as sludge handling and disposal requirements, acid requirements for neutralizing the effluent and filtration requirements to remove suspended solids in the effluent. Chemical-biological processes

offer promising improvements in operational efficiency through lower costs, increased effectiveness, reduced solids disposal problems, and a minimum of plant changes. In both approaches, the role of lime or alum recovery and reuse plays a significant role in affecting costs. Of the two chemicals, lime currently displays more potential for economical recovery through recalcination and CO_2 byproduct recovery for recarbonation.

An evaluation of phosphorus removal cost data for either type of treatment in the 90- to 95 percent removal range shows that for a typical 10 MGD plant, $.05/1000 gal., or less, will accomplish the goal today. Factors relating to the composition of the local water, methods of sludge disposal, methods of chemical recovery, etc., have been considered in the figure quoted above. Considering the progress already made and the large amount of laboratory and pilot plant work in progress, there is little reason to doubt that the economics of present and future systems will improve.

The total cost breakdown for a typical

tertiary chemical phosphate removal process treating secondary effluent is given below. It includes capital costs, operating and maintenance cost for equipment, chemical cost, sludge disposal, and recalcining of sludge.

It is significant to note that considerable savings are available in recalcining the sludge. Another point of interest is that over 50 percent of the total cost is taken up by chemical costs.

Smith portrays a similar cost breakdown (Figure 3) graphically for coagulation and sedimentation after lime addition. Chemicals required were taken as 300 milligrams per liter of hydrated lime and 50 milligrams per liter of ferrous sulfate.

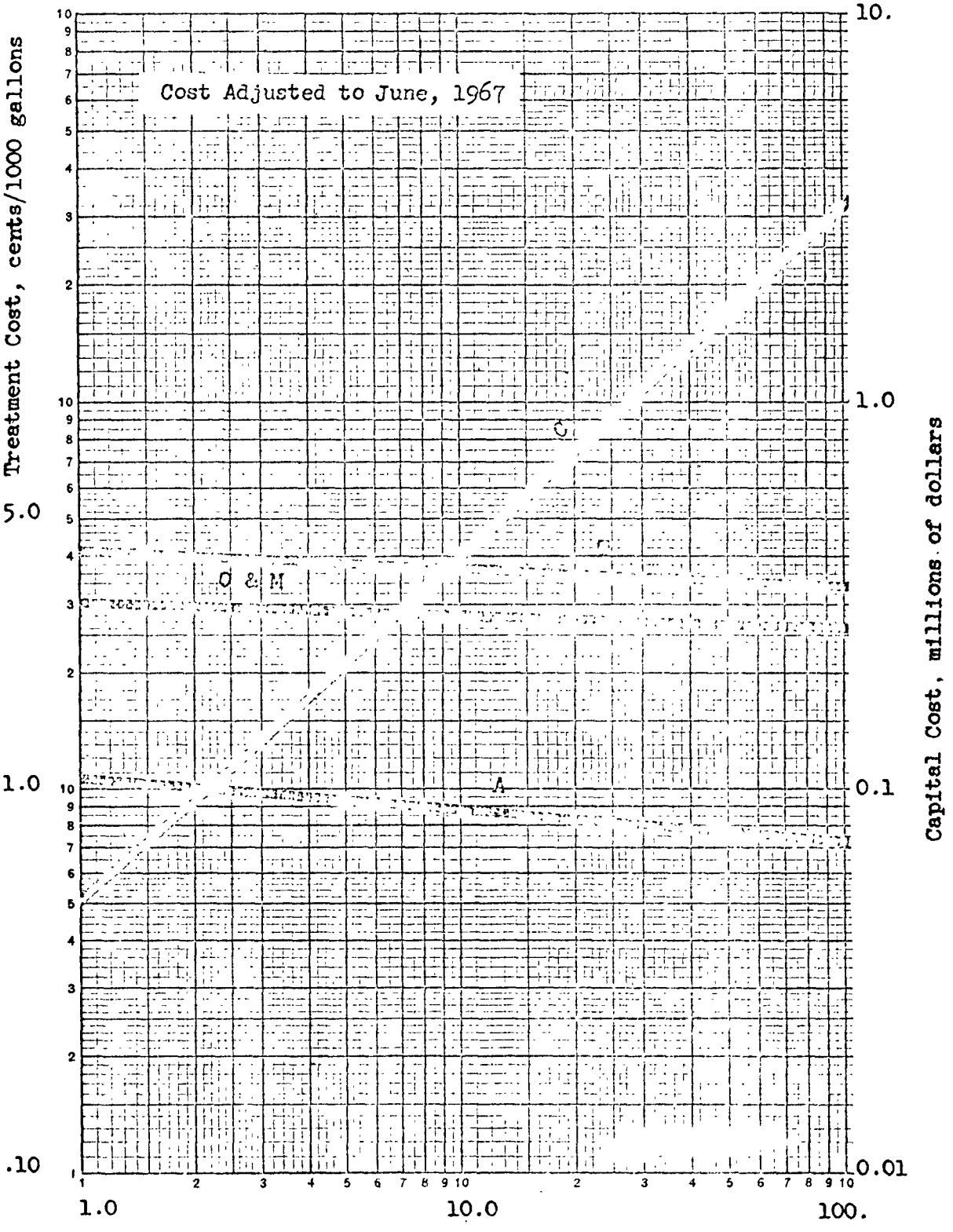
TOTAL COST OF PHOSPHATE REMOVAL

(Cents per 1000 gallons)

	Size of Plant			
	1.0 mgd	10.0 mgd	100.0 mgd	1.0 bgd
Capital Amortization	.97	.79	.65	.53
Land Amortization	.09	.09	.09	.09
Operating and Maintenance	.41	.14	.08	.07
Cost of Chemicals				
Lime	1.75	1.75	1.75	1.75
Iron Salt	.87	.87	.87	.87
Cost of Sludge Disposal by hauling to land fill 25 mile one-way trip	.67	.67	.67	.67
TOTAL	4.76	4.31	4.11	3.98
Savings if sludge can be recalcined	- .96	- .96	- .96	- .96
TOTAL (With Recalcing)	3.80	3.35	3.15	3.02

Figure 3. SOLIDS REMOVAL BY COAGULATION & SEDIMENTATION

Capital Cost, Operating & Maintenance Cost, Debt Service
vs.
Design Capacity



C = Capital Cost, millions of dollars
A = Debt Service, cents per 1000 gallons(4 1/2 - 25 yr.)
O & M = Operating and Maintenance Cost, cents per 1000 gallons
T = Total Treatment Cost, cents per 1000 gallons

DR. LEON W. WEINBERGER

SUMMARY AND CONCLUSIONS

New concepts, processes, and techniques for the removal of phosphate at modest cost in the municipal wastewater treatment plant are a technical reality today and will be broadly applied on a commercial scale in the very near future. Operational experience in the United States has demonstrated that chemical (tertiary) treatment will reliably remove 90 to 95 percent of the total phosphate present in municipal wastewater. Side benefits are also achieved because other pollutants are reduced substantially in the process. Cost and performance will undoubtedly improve as operational experience becomes more widespread.

Both the cold lime and alum chemical treatments are straightforward, reliable, and easily controlled to produce a predictable effluent quality. The choice of either process is dictated by local considerations such as sludge disposal or utilization, neutralization (pH) requirements, and solids removal requirements. Only a brief engineering study is

required to develop the best method at a specific location.

Chemical treatment may also be integrated with conventional biological treatment by chemical addition at either the primary sedimentation stage or the activated sludge stage. Chemical-biological treatment should result in improvements of current conventional or tertiary processes so that significant cost reductions will be achieved in the near future. Potential net costs of less than $03/1000 gal. ($30/MG) appear readily attainable and operating data from full scale plants should be available within one year. Integrated treatment can generally be assumed to require minimum plant modification to existing facilities with resultant phosphate removals of the order of 90 percent.

In general, future phosphate removal costs will decline and commercial firms have even projected that net costs of less than $01- to $02/1000 gal. ($10-20/MG) may be realized. Effective treatment for phosphate removal will simultaneously yield other pollution control

benefits through removal of other impurities.

In conclusion, currently available technology allows us to design for phosphate removal on a rational basis and to select the most economical system for a given locality based upon a brief preliminary engineering study. Phosphates can be removed today from municipal sewage at a cost of less than $05/1000 gal. ($50/MG).

Appendix A

Treatment Plants Utilizing Chemical Processes to Remove Phosphorus

Lake Tahoe - California

The Lake Tahoe tertiary treatment plant started operation in the summer of 1965 at 2.5 MGD capacity. Secondary effluent from an activated sludge plant was renovated using 200 ppm of alum added just ahead of two mixed-media filter beds operated in series and followed by granular activated carbon contactors. In addition to reducing ABS, BOD, and COD to potable water standards, phosphate reduction

from 25 parts per million to less than 1 part per million was consistently achieved. The plant was recently expanded to 7 MGD capacity, and has started operation at 4 MGD using the same alum tertiary process, however, they will soon convert to the use of the cold lime process using a lime dose of 400 parts per million total, divided between the primary and tertiary systems. The tertiary precipitation step will be followed by recarbonation and filtration through two mixed-media filter beds in series, and activated carbon. Again the effluent phosphate content is anticipated to be reduced to levels of 1 to 0.1 parts per million while the bulk of the lime will be recovered and reused. The cost for the cold lime process, including infiltration, of the recarbonated effluent, is projected at 10.46¢/1000 gallons at 7.5 MGD using a total lime dose of 400 parts per million. It should be noted that the cost of lime and other costs at Lake Tahoe is appreciably greater than in most communities. The original alum process (with separation beds), experienced costs of 9.8¢/1000 gallons at the 2.5 MGD scale.

DR. LEON W. WEINBERGER

Lansdale - Pennsylvania

Cooling water makeup (0.3 MGD) using secondary sewage effluent is being utilized at Lansdale, Pennslyvania. The process for conditioning the water, prior to use as cooling water makeup, consists of alum addition followed by separation beds. This is essentially the same technique as demonstrated at Lake Tahoe. In addition to improving the general quality of the water, phosphate removal efficiencies of 90 percent are being readily achieved.

Las Vegas - Nevada

In Las Vegas, Nevada, the Nevada Power Company has two wastewater renovation plants which treat nearly 4 MGD of secondary effluent in a clarification operation. These facilities have been in operation since 1961. The cold lime treatment process is used to reduce phosphate to acceptable levels for cooling water use, with a lime dose of 180 parts per million. Well over 95 percent removal of phosphates is achieved.

DR. LEON W. WEINBERGER

Amarillo - Texas

In the southwestern and western parts of the United States, several industrial enterprises and public utilities are renovating secondary effluents from municipal sewage plants, as water conservation economics suggest. In Amarillo, Texas, the Southwest Public Service Company is using the cold lime process as tertiary treatment for removing scale forming phosphate from the effluents prior to use as cooling water. Acidification for pH reduction after precipitation is accomplished by sulfuric acid addition in lieu of recarbonating as contemplated at Tahoe. More than 4 MGD of effluent is processed daily to produce a 1 part per million phosphate cooling water. This represents an average phosphate removal efficiency of nearly 98 percent, and requires a lime dose of 300 parts per million to assure consistent removal.

Piscataway - Maryland

A newly constructed 5 MGD activated sludge plant in the Potomac River Basin is to be

expanded shortly to include tertiary treatment. The tertiary process will consist of lime precipitation, recarbonation with clarification, filtration, and activated carbon treatment. As in Tahoe both spent lime and activated carbon are to be regenerated. Costs and performance are also anticipated to be similar. However, there will be significant design differences in the carbon contactors (downflow) and filtration beds used (upflow, single parallel beds).

Routing of the regenerated phosphate lime is also to be different. It is currently anticipated to be beneficially waste a portion of the regenerated phosphate lime to the sludge dewatering system. Also means of artificially adding hardness to the secondary effluent is planned in order to demonstrate the optimum conditions for phosphate removal. While 400 parts per million lime dosage is scheduled for use at Tahoe, only 200 parts per million of lime will be used initially at Piscataway. The cost of the phosphate removal tertiary system, excluding the filtration operation, at Piscataway is anticipated to result in a total cost of less than 5¢/1000 gallons.

APPENDIX B

Selected Operational Phosphate Removal Process Experience in the United States

Location	Status	Size MGD	Type	Process	Actual or Projected Cost @ 10-20 MGD ¢/1000 gal.	Actual or Projected Phosphate Removal Efficiency
Lake Tahoe, Cal.	Operational	2.5-4	Chemical	Alum Tertiary with Separation Beds	< 9¢	> 95 (0.1-1.0ppm in effl.
Nassau County, Long Island, N.Y.	Operational Since 1965	0.6	Chemical	Alum Tertiary with Separation Beds	< 7¢	> 60
Pomona, Cal.	Operational	3	Chemical-Biological	Alum Secondary with Activated Sludge	< 5¢	> 80
Lansdale, Penna.	Operational	0.3	Chemical	Alum Tertiary with Separation Beds	< 10¢	> 90
Wayne, Michigan	Operational for Short Period	45	Chemical-Biological	Alkaline waste Calcium Chloride to Raw Sewage	-	> 80 (jar test)
Lake Tahoe, Cal.	Startup Feb., 1968	4 to 7.5	Chemical	Lime Tertiary with Separation Beds	< 9¢	> 95 (0.1-1.0ppm in effl.
Las Vegas, Nevada	Operational since 1961 (2 sites)	4	Chemical	Lime Tertiary with single clarifier	< 4¢	> 95 (0.5 ppm in effl.)
Washington, D.C.	Operating	Pilot Plant	Chemical	Lime Tertiary with dual clarifiers and lime recovery	< 4¢	> 95

Location	Status	Size MGD	Type	Process	Actual or Projected Cost @ 10-20 MGD ¢/1000 gal.	Actual or Projected Phosphate Removal Efficiency
South Central Region	Prior Operations 5 sites	Pilot Plant	Biological	Activated Sludge Phosphate Uptake	$<1¢$	to 87
Black River Plant, Baltimore	Operational test	20	Biological	Activated Sludge Phosphate Uptake	$<1¢$	>90
Irvine, Cal.	Operational	Pilot Plant	Biological	Activated Sludge, Phosphate Uptake Acid Elutriation Chemical removal	$<5¢$	~ 90

APPENDIX C: FWPCA SPONSORED RESEARCH AND DEVELOPMENT PROJECTS IN PHOSPHATE REMOVAL (CURRENT)

Location	Scale MGD	Type	Description
Washington, D. C.	0.1	Chemical	Lime Process. Precipitation-clarification, recarbonation, clarification, and filtration polishing. Startup 1967.
Lake Tahoe	7.5	Chemical	Lime Process. Precipitation-clarification, recarbonation, filtration polishing. Operational early 1968.
Piscataway, Md.	5.0	Chemical	Lime Process. (as in 1 above) startup 1969.
Detroit, Michigan	0.1	Chemical	Lime Process. Applied to activated sludge desorbed liquor. Also to test ferrous phosphate precipitation from liquor.
Irvine, California	1.0	Chemical-Biological	Activate sludge phosphate uptake and acid elutriation of sludge concentrate. Alum precipitation of leach liquor phosphate.
Wayne, Michigan	< .1	Chemical-Biological	Alkaline calcium industrial waste effects on phosphate removal from raw sewage. Prior experience showed phosphate removal in primary system.
Trenton, Michigan	< .1	Chemical-Biological	Optimize activated sludge phosphate uptake. Testing of aluminum ferric, ferrous, and calcium salts for phosphate precipitation.

APPENDIX C: FWPCA SPONSORED RESEARCH AND DEVELOPMENT PROJECTS IN PHOSPHATES REMOVAL (CURRENT), CON.

Location	Scale MGD	Type	Description
Ada, Oklahoma	_	Biological	General studies and tests on activated sludge parameters affecting phosphate uptake by bio mass.
Milwaukee, Wis.	115	Biological	Optimize activated sludge phosphate uptake. Parameters for joint municipal-industrial plant.
Chino, California	3	Biological	Activated sludge phosphate uptake in high organic loaded system.

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DR. WEINBERGER: This presentation today is not a research paper of possible answers, but what it represents is some practical results resulting from research. What I am to present is what can be done now and in the immediate future. I will discuss waste treatment for phosphorus removal.

Wastewater treatment facilities can be designed, built and operated to remove at least 80 percent of the phosphorus found in municipal wastewaters. Using available technology and through laboratory, pilot

plant, and full-scale plant data reported in the open literature--I have a list of references--design and consulting engineers can design treatment facilities with a high degree of reliability in projected cost and performance. Equipment is being designed and sold which will achieve at least 80 percent removal. The 80 percent figure is conservative, very conservative. The evidence indicates that 90 to 95 percent, and even more, phosphorus can be removed effectively.

Any confusion as to the efficacy of phosphorus removal probably stems from the fact that many methods have been put forth and are under study. Some of these are chemical processes such as lime, alum, and so forth; some of them are biological processes using activated sludge plants or algal ponds; some of these combined biological-chemical processes, and a whole host of other processes, including ion exchange, electrodialysis, reverse osmosis, spraying on the land, electrochemical, and even distillation.

A summary for deficiencies is presented in Table 1.

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The treatment process which can be designed, constructed, and operated with greatest confidence today for phosphorus removal would employ chemical treatment. A typical flow diagram is shown in Figure 1. Certain types of combined chemical-biological treatment systems will also be ready for application soon. These processes are illustrated in Figure 2.

Figure 1 represents a conventional treatment plant with primary treatment followed by a biological process and then a chemical treatment stage as a tertiary stage. The biological-chemical that I referred to on Figure 2 represents also a primary secondary or biological treatment plant, but in this case chemicals are introduced either in the primary treatment plant or directly into the activated sludge plant.

Chemical treatment, again referring to Figure 1, may be applied as a tertiary treatment or independently as a separate treatment for various wastewaters. Chemical treatment may also be used to eliminate or

reduce the recycle of phosphorus from digester supernatants or from thickener liquids.

The two common types of chemical treatment for phosphorus removal are: (1) Alkaline removal with lime, and (2) Adsorption or precipitation with metallic hydroxides.

Typical phosphorus removals for either type or combination of chemical treatments readily exceed 90 percent. The principal advantage in chemical treatment lies in the close control that can be maintained in actual plant operation. Another advantage is that laboratory data will predict dosage levels for particular phosphate residuals as well as settling rates for clarifier designs. It should be noted that in addition to phosphorus removal, chemical treatment will also result in significant reduction in organic and inorganic turbidity, reduction in BOD and COD, that is biological and chemical oxygen demands, and reduction in bacterial numbers. Chemical treatment can be effective even with fluctuations in the preceding conventional processes and should maintain a more uniform effluent quality

than other phosphorus removal processes. In Appendix A, I have descriptions of plants that have successfully utilized chemical phosphate removal.

The chemical-biological treatment may be illustrated by Figure 2 and in Process 2(a) it involves the addition of a precipitant to accomplish most of the phosphorus removal in the primary tank with additional removal of phosphorus in the biological phase. A recent study by Buzzell and Sawyer shows that lime treatment of raw wastewater can remove 80 to 90 percent of influent total phosphorus. Laboratory data by Albertson and Sherwood indicate that even more economical benefits are achieved when solids are recycled around the primary treatment unit. Advantages in this approach include improved clarification and BOD removal in addition to improved phosphate removal. Lime recovery may be used to reduce costs even further. Several new plants destined to utilize these processes have been designed, including one in Rochester, New York.

Process 2(b) involves the addition

of minerals directly into the aeration tank which results in the formation and precipitation of slightly soluble phosphorus compounds. Additives such as aluminium or iron salts cause no interference in the biological activity, and the mixing and residence times provided by the aerator allow sufficient time for formation of precipitates. There has been no increase in the volume of the sludge produced because of improvement of the settling characteristics of the mixed liquors. This latter process has been referred to by Barth and Ettinger as "mineral addition."

The Federal Water Pollution Control Administration has just completed a field study of the mineral addition process at the Xenia, Ohio, wastewater treatment plant. The data show that the plant normally removes about 20 percent of the influent phosphorus. With the addition of sodium aluminate, removals of 85 to 92 percent were obtained. When we stopped adding the chemicals, the plant returned to the normal 20 percent removal. The chemical cost of phosphorus removal was some five cents per

thousand gallons, and considering that this was a field investigation, using makeshift equipment, the results show promise when this approach is applied in a more controlled situation.

I mention this particular process because it presumably would not require the addition of any new treatment facilities other than chemical additives.

The table given in Appendix B presents a status summary of various operational projects in the United States designed for phosphate removal utilizing biological, chemical, or chemical-biological means. This Administration is actively participating in demonstration projects for phosphorus removal through research and development grant funds. A list of these projects is presented in Appendix C.

Current operational experience indicates that tertiary chemical treatment costs will be affected by local factors such as sludge handling and disposal requirements, acid requirements for neutralizing the effluent and filtration requirements to remove suspended solids in the effluent. Chemical-biological

processes offer promising improvements in operational efficiency through lower costs, increased effectiveness, reduced solids disposal problems, and a minimum of plant changes. In both approaches, the role of lime or alum recovery and reuse plays a significant role in affecting costs. Of the two chemicals, lime currently displays more potential for economical recovery through recalcination and carbon dioxide byproduct recovery for recarbonation.

An evaluation of phosphorus removal cost data for either type of chemical treatment in the 90 to 95 percent removal range shows that for a typical 10 million gallon per day plant, 5 cents per 1,000 gallons or less will accomplish the goal today. Factors relating to the composition of the local water, methods of sludge disposal, methods of chemical recovery, etc., have been considered in the figure quoted to you. Considering the progress already made and the large amount of laboratory and pilot plant work in progress, there is little reason to doubt that the economics of

present and future systems will improve.

The total cost breakdown for a typical tertiary chemical phosphate removal process treating a secondary effluent is given below. It includes capital costs, operating and maintenance cost for equipment, chemical cost, sludge disposal, and recalcining of sludge.

Gentlemen, the table indicates that for a one million gallon a day plant the total cost of the phosphate removal would be about 4.8 cents per 1,000 gallons, at a 100 million gallon a day scale it would be about 4.1 cents, and if we even went to a one billion gallon a day plant it would be about 4 cents a thousand gallons.

I would not normally have shown these parts in two significant figures, but this was done to indicate some of the differences in operating and maintenance.

You will note that a significant saving can reduce these costs today, and I am talking about costs today, that with recalcining, costs can be reduced to below 4 cents a thousand gallons. You will note from this table that more

than 50 percent of the cost is attributable to the chemical costs. This helps explain why scale does not mean as much in this type of treatment as it would in conventional primary or biological treatment.

It is significant to note that considerable savings are available in recalcining the sludge. Much of this advantage results from the fact that you don't have a sludge problem or it is minimized.

Smith at our Cincinnati laboratory portrays a similar cost breakdown, which is shown in Figure 3, which graphically illustrates the coagulation and sedimentation process after lime addition. His costs were based on chemical additions of 300 milligrams per liter of hydrated lime and 50 milligrams per liter of ferrous sulfate.

I might mention that the method for computing these costs is given, including the debt services allowances, and point out to some of you that the costs are adjusted to June 1967 and based on the cost of lime of about $18.50 per ton, which, of course, would have

an effect on the costs.

Summarizing, new concepts, processes, and techniques for the removal of phosphate at modest cost in the municipal wastewater treatment plant are a technical reality today and will be broadly applied on a commercial scale in the very near future. Operational experience in the United States has demonstrated that chemical treatment, chemical after biological, will reliably remove 90 to 95 percent of the total phosphate present in municipal wastewater. Side benefits are also achieved because other pollutants are reduced substantially in the process. Cost and performance will undoubtedly improve as operational experience becomes more widespread.

Both the cold lime and alum chemical treatments are straightforward, reliable, and easily controlled to produce a predictable effluent quality. The choice of either process is dictated by local considerations such as sludge disposal or utilization, neutralization (pH) requirements, and solids removal requirements. Only a brief engineering study is

required to develop the best method at a specific location.

Chemical treatment may also be integrated with conventional biological treatment by chemical addition at either the primary sedimentation stage or the activated sludge stage. Chemical-biological treatment should result in improvements of current conventional or tertiary processes so that significant cost reductions will be achieved in the near future. Potential net costs of less than 3 cents per 1,000 gallons appear readily attainable and operating data from full scale plants should be available within one year. Integrated treatment can generally be assumed to require minimum plant modification to existing facilities with resultant phosphate removals on the order of 90 percent.

In general, future phosphate removal costs will decline and commercial firms have even projected that net costs of less than 1 to 2 cents per 1,000 gallons may be realized. Effective treatment for phosphate removal will simultaneously yield other pollution control benefits through removal of other impurities.

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In conclusion, currently available technology allows us to design for phosphate removal on a rational basis and to select the most economical system for a given locality based upon a brief preliminary engineering study. Phosphates can be removed today from municipal sewage at a cost of less than 5 cents per 1,000 gallons, which represents some $50 per 1,000,000 gallons or less than 1 cent per capita per day.

Thank you.

MR. STEIN: Thank you, Dr. Weinberger. That was an excellent statement indeed, and I think we have some new material here, because this is the first I have heard this. As stated in this way I think we are faced with a significant new concept and I hope a great one.

Are there any comments or questions?

Mr. Holmer.

MR. HOLMER: As I look at Table 1 on this report, Dr. Weinberger, I notice that of this rather extensive number of alternative methods of treatment--and I recognize that this relates to the kinds of wastewater that are coming in, and so on--that column 3 is headed

"Scale of Operation," and of these only a very few are listed as in full-scale operation and that for those that are in full-scale operation the percentages of removal are on the order of, well, just to read a few of them, 47 percent, 10 to 30 percent, 30--well, you know them as well as I do.

DR. WEINBERGER: Yes.

MR. HOLMER: Are we far enough along to be able--is there any hesitation in your conclusions that we have been into full-scale operation sufficiently to warrant the conclusion that we can achieve 90 percent consistently in full-scale operation at these prices for all wastes?

DR. WEINBERGER: Mr. Holmer, the specific answer is there is no doubt in my mind that we can accomplish that.

Referring to Table 1, it is significant to note that those figures that you refer to deal with the biological process. As I indicated in my opening remarks, I came here today not to project too far into the future as to what might be accomplished through

research, and accordingly confined my remarks to a process which will work and which will work today. In the future, and I have indicated we have a very extensive research and development program, we will undoubtedly improve our technology in this area as well as all others.

But if one looks at the chemical processes in Table 1, if one looks at the removals of the phosphates by chemical means, which is the one that I am so certain about, one sees that the removals are consistently above 90 percent, 93 percent, 99 percent, 97 percent, 94 percent, and so forth, with one exception, and that was the exception reported by Sawyer and Buzzell; but again I would point out that their 77 or 78 percent removal was only based upon chemical treatment of primary sewage. It was not followed by a second stage of biological treatment.

MR. HOLMER: Our concern is a very real one. As you are aware, Wisconsin is quite anxious to find the most feasible means of dealing with these. I notice that a number

of these lab experiments have been participated in by Mr. Rohlich, who is a member of our Board as well as one of the leaders in this whole business. We have investigations at Milwaukee and Green Bay on a major scale.

One of the studies in which Mr. Rohlich was involved we know when it moved from the lab stage to the pilot stage, this is the alum-lime experiments, dropped from the 95 percent reported here to 75 percent, and if we were to move in the same proportion in each of these, we have got some problems.

And I am wondering whether we are ready to embrace fully and promptly at this time full-fledged involvement in the chemical process. I recognize you are pretty confident of this, and I appreciate that.

DR. WEINBERGER: The four installations that are referred to, one of the installations is Lake Tahoe, where phosphate is being removed. Three other full-scale installations for phosphorus removal are reported. In this case the phosphorus removal was for purposes of preparing sewage effluent for boiler feed water. The

fact that it was for a different purpose does not negate the fact that these degrees of removal are being achieved on a routine basis.

MR. POSTON: Mr. Holmer, I might comment to the effect that a couple of weeks ago I was in Niagara Falls and Dwight Metzler, your counterpart in the State of New York, in giving testimony to the International Joint Commission about phosphate removal indicated that there were some 20 plants in New York presently being designed for phosphate removal.

I was particularly interested in Dr. Weinberger's statement that indicated to me that we could get better removal of phosphates after secondary treatment. Did I understand that right?

DR. WEINBERGER: No, Mr. Poston, what I was suggesting here, that if one went to phosphate treatment after the conventional type of primary and biological treatment as a result of removing phosphorus in the tertiary stage, you would also remove some additional suspended solids which normally would be

discharged. You would also be having some bacterial kills because of the additional lime treatment.

In other words, what I am saying here is that there are more benefits than just phosphate removal.

MR. STEIN: Mr. Oeming.

MR. OEMING: Dr. Weinberger, I would like to clear up what seems to me to be a discrepancy between Appendix C and your table of amounts treated--just a moment until I get it straightened out--Appendix C and Appendix B.

In Appendix B you mention Wayne, Michigan, as an operational phosphate removal process of 45,000,000 gallons a day, chemical-biological. And in Appendix C you indicate, I think, a tenth of a million gallons per day. Could you clear that up?

DR. WEINBERGER: Larry, I am sorry.

MR. OEMING: Let's start over.

DR. WEINBERGER: All right.

MR. OEMING: In Appendix B under Wayne, Michigan, you indicate that Wayne is an operational phosphate removal process of

45,000,000 gallons a day treatment. Have you found that?

DR. WEINBERGER: Yes, sir.

MR. OEMING: Now, in Appendix C you mention Wayne again and you have it as a tenth of a million gallons a day.

DR. WEINBERGER: Let me explain that. I think I can do that readily.

Under Appendix C, Larry, we are talking about some of the existing projects that we have, and of course at the tenth of an MGD scale. In Appendix B, if we follow across, I think the indication is that some of the removals are based on jar tests but that there have been some very short periods. I think it is indicated there that for very short periods they have had full-scale operations.

MR. OEMING: This didn't mean, to you at least, that Wayne is operating a full-scale plant?

DR. WEINBERGER: No, sir. No, sir.

MR. OEMING: All right, this is the point.

DR. WEINBERGER: No, sir.

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MR. OEMING: Lee, as I look at the costs of phosphate removal, it strikes me that iron salts get you down into a cheaper range of cost here. Isn't that right?

DR. WEINBERGER: Larry, I think again the point that I wanted to make here was that I think in any one instance for chemical treatment one might have a balance of chemical costs, that one can achieve these removals through lime, through alum, through iron, and combinations of those three, and the purpose here is to indicate that these have been successful, but in any one case one would have to look at the economics.

MR. OEMING: I see.

Well, Dr. Weinberger, I personally want to thank you for a very elucidating statement here, and I think one that has been a long time overdue, not criticizing you, but it has been a long time overdue. And I just want to say further, speaking for Michigan, that in addition to the instances you have cited we can confirm the principles that you have presented here.

DR. WEINBERGER: Thank you. I

appreciate that.

MR. STEIN: Are there any other comments or questions?

I recognize, you know, that something like this may have been long overdue, and I have been waiting for it as much as anyone, but I don't think you can get out the statement until you are sure of the facts.

Do you have something, Mr. Poole?

MR. POOLE: I want to comment a little.

MR. STEIN: Yes.

MR. POOLE: First, Dr. Weinberger, I notice in the body of your report for chemical treatment you come down to 5 cents a 1,000 gallons, which includes chemicals, sludge disposal and everything else.

In Appendix B, however, you show Lake Tahoe with chemical at 9 cents a 1,000, Nassau County Chemical at 7 cents a 1,000, Lansdale, Pennsylvania, at 10 cents a 1,000, Lake Tahoe's second plant, which is going to start up next month or I guess this month now, at 9 cents a 1,000, and I am a bit

curious as to what, in view of those cost figures, brought you to the conclusion that this could be done for 5 cents a 1,000.

DR. WEINBERGER: Mr. Poole, speaking specifically of Tahoe, because I think there has been the most published information regarding the Tahoe installation, if one reviews the Tahoe costs, this is a real plant, a real cost, the cost of lime in Lake Tahoe, as an example, is roughly double what it would be almost any place else in the United States. The costs in Lake Tahoe across the board are extremely high, and, therefore, what we have done is, of course, indicated what those costs would be.

In some of the other cases in Appendix B, some of these cost figures, although they have been actual or projected to a larger scale operation, some of these are for experimental purposes and some of these are rather small plants.

But the Lake Tahoe figures, and I would be very happy to make those available, in going through actual costs it is quite

easy to see where lime is some $15 a ton, the cost will be below 5 cents.

MR. STEIN: Mr. Poole has been out to Lake Tahoe with us. I can say that at Lake Tahoe my hotel room is double what I pay here.

(Laughter.)

MR. POOLE: I have a second comment or observation, I guess this is, instead of a comment.

You are giving us now with considerable reassurance on your part--and having known you as long as I do this gives me considerable reassurance as to the information you presented here today--but if I followed you correctly you are saying that you could remove from 80 percent of the phosphates up, by chemical processes, at 5 cents a 1,000. Then you create a tremendous problem for State administrators when right over at the end of your summary and your conclusions you say that within a year or so a combination of chemical treatment with conventional biological treatment will go down to 3 cents a 1,000 and that in all probability eventually to 1 or 2 cents

a 1,000.

I hope you appreciate that this puts a fellow like me, if I go to South Bend, Indiana, just as a case in point, at quite a disadvantage in saying that I expect you to start on a chemical process now that is going to cost you 5 cents a 1,000, when they have, we will say, 35,000,000 gallons of sewage, but maybe by next year there will be another process by which you could do it for 3 cents a 1,000.

DR. WEINBERGER: Mr. Poole, I recognize the problem that I may have created, and this was my only departure, I believe, in terms of making any projections. But I felt compelled to do this in the light of some of the advances being reported by people who are in the business of providing pollution control equipment. As Mr. Stein has indicated, a number of these plants are under design and the projected costs for these are much lower than the 5 cents a 1,000 gallons. I think that if one were to proceed today to hire engineers and have engineers proceed with the design and for them indeed to make the

appropriate selection among alternatives, the costs even today would be below the 5 cents.

MR. STEIN: Are there any further comments or questions?

MR. HOLMER: Yes, sir.

MR. STEIN: Yes.

MR. HOLMER: As has been clearly indicated, a good share of the area in each of our States is outside of the Lake Michigan Basin. I think we have been somewhat persuaded that the phosphorus problem for the Lake Michigan Basin is an extremely serious one. I am not sure who ought to deal with the question.

But is phosphate removal, phosphorus removal, as important for every other receiving water as it is for the receiving waters in the Lake Michigan Basin?

MR. STEIN: Well, I don't know if Dr. Weinberger wants to talk about that, but I, as you know, have had considerable experience with the hard nuts and bolts of every major case throughout the country and I find that is a significant problem everywhere. It is

ubiquitous. I think the key problem and the hard residual problem we are finding all over the country today with no variant is the nutrient problem. If any of you know an organic waste or municipal waste problem where that isn't the case, except perhaps in ocean outflow, I would like to know about it.

Yes.

MR. POSTON: I would like to comment to the effect that I think it is a particularly important problem in Lake Michigan because, as was emphasized by Dr. Baumgartner this morning, if we let Lake Michigan deteriorate and become eutrophic, we can expect this problem to persist for 1,000 years, even though corrective measures are taken; whereas in a stream the water flows away and we can change the picture, the biota in the stream, in a relatively short period of time.

MR. HOLMER: In a sense I preferred Murray Stein's answer, because it simplifies things for a State administrator--

MR. STEIN: Yes.

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MR. HOLMER: --not to have to distinguish.

(Laughter.)

MR. STEIN: That is right. Now, I think in an inland State such as yours you will have that problem. I imagine a coastal State may have an easier problem on this phosphate removal operation.

But for an inland State or an inland river, it is right with you wherever we go.

MR. HOLMER: On his lists in Appendices B and C and A, I guess, only Nassau County appears as a coastal potential, and so this was what led me to my question.

DR. WEINBERGER: I might mention that the reason for Nassau County doing this is because of a ground water injection.

MR. STEIN: Yes. They really can't afford to put their wastes out into the ocean. They are hard put to find any water sources on Long Island and they have to depend upon their wastewater and hope to put it back in and get it out again.

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Are there any further comments?

MR. OEMING: Dr. Weinberger, you haven't touched in your statement, perhaps you aren't qualified to speak about it, but we are informed that there has been a committee established between the soap and detergent industry and the FWPCA. I am not sure that I understand everything this committee proposes to do or where it is heading and when. I wonder if you are the proper person to discuss this here or should we address our question to somebody else?

DR. WEINBERGER: Larry, I am afraid I am going to have to answer, since I am Vice-Chairman of that committee.

(Laughter.)

MR. STEIN: That committee knows who to put in charge of bubbles.

(Laughter.)

DR. WEINBERGER: Let me try and give a little background to the formation of that committee, which was established by Secretary Udall in cooperation with members of the Soap and Detergent Producers and Manufacturers.

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Recognizing that the matter of accelerated eutrophication and the problem related to the sources of nutrients and their effects was a very complex problem--there are many contributors to this problem--the Secretary indicated that every effort should be made to get the full cooperation and participation of all of those who can make a contribution to the solving of this problem. Accordingly, a joint task committee was established, a technical committee, for the purposes of trying to accelerate research, coordinate the research, on all aspects of the problems associated with eutrophication. That is a technical task committee made up of industrial representatives as well as Federal representatives.

One of the things which this group has undertaken and announced just a month ago was the calling together of some of the most competent people throughout the world to help us develop an algal growth potential test so that we would be able to evaluate the effects of any chemical which might be discharged into a lake. I think this group is looking at the

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total matter of eutrophication.

Does that, Larry, answer the question or do you want something specific?

MR. OEMING: Well, I am sorry, Dr. Weinberger, but I don't think it does.

DR. WEINBERGER: I am sorry, Larry.

MR. OEMING: Let's start from the basic premise here, there are phosphate builders in detergents.

DR. WEINBERGER: All right.

MR. OEMING: Now, is a part of this project to determine whether something can be done to alter the structure of the detergents so that you don't use phosphate builders or something else that has an equal pollution potential?

DR. WEINBERGER: Larry, the Soap and Detergent Association announced within the last 30 days that industry was intensifying their efforts to find substitutes or partial substitutes for phosphate builders. This was announced within the last 30 days, I believe, so that as a committee, as an agency, we, of course, are quite concerned that all steps

should be taken to reduce phosphate, although again my remarks here were addressed specifically to the matter of treatment. It is obvious, I hope, that we have got to intensify our efforts to control phosphorus from land runoff We have got to use whatever means that we can.

One of the suggested solutions, one of the possible solutions, is to also reduce the amount of phosphorus that might be in our detergents, and industry has indicated that they are proceeding.

I might say that I attended a meeting just last Thursday where two products--and I would like to emphasize these were quite experimental, in very early development stage--two products were reported which might be substitutes or partial substitutes for the kinds of phosphates currently available. This is a long-term process, however.

Does that answer it?

MR. OEMING: Thank you.

MR. STEIN: Are there any further comments or questions?

Before we recess, I think we have

gotten possibly, as I see it, the key to the theory behind the presentations of the Federal Government point of view. That is, aside from the usual pollution problems--and you have heard of their interference with recreation, et cetera, mentioned in the Federal report--the major and significant problem we have to deal with here is the accelerated eutrophication or premature aging of Lake Michigan. This is due in large measure, as I understand the Federal presentation, to discharges from municipal and industrial sources. The key element that the scientists believe can be controlled to show this up is the control of the discharge of phosphorus and the amount of phosphorus in Lake Michigan.

There are indications that Lake Michigan is definitely showing the signs of accelerated eutrophication, according to Dr. Bartsch's report, and according to Dr. Baumgartner the current pattern in the lake is such that every one seems to be interconnected with the next one, all the bordering States, and we have to view the States as a whole.

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As in all cases, the next implication is you have to deal with this source by source, municipal and industrial.

Dr. Weinberger has added a new element--something that I have never heard of before and which we have been waiting a long time to hear--that wastewater treatment facilities can be designed, built and operated to remove at least 80 percent, and in many cases 90 percent of the phosphorus found in municipal wastewaters at a reasonable cost.

At this stage this is, as I see it, the essence of the Government presentation on the eutrophication. We will be hearing other comments and other statements, but if anyone disagrees with this or has questions on it, I would suggest in his presentation he raise this point. I think this is a relatively straightforward presentation. We have the disease, we have the diagnosis, and we have a prescription for treatment at a

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reasonable cost, and I think with that kind of blueprint we can move forward unless there are some significant changes.

With the presentation of a case of this kind, we are all faced with a challenge. I am just trying to state the case without coming to any conclusions. I think within the next week or so as we work this over this is the problem we must meet head on, and if this case cannot be disputed, I leave the alternatives of where we go on it to you.

We will stand recessed for 10 minutes.

(Recess.)

MR. STEIN: May we reconvene?

Mr. Poston.

MR. POSTON: Mr. Schneider will now draw the conclusions and recommendations.

Mr. Schneider.

These are the Federal conclusions and recommendations.

(Laughter.)

MR. HOLMER: Are these not the

conclusions of the Federal Water Pollution Control Administration or are these the conclusions of the Federal Government?

MR. POSTON: These are the conclusions of the Federal Water Pollution Control Administration.

MR. HOLMER: O. K.

STATEMENT BY R. J. SCHNEIDER

CONCLUSIONS AND RECOMMENDATIONS

FEDERAL WATER POLLUTION CONTROL ADMINISTRATION

MR. SCHNEIDER: Thank you, Mr. Poston. Chairman Stein, conferees, ladies and gentlemen.

In presenting the conclusions, I would like to invite your attention to the wall map where locations mentioned in the conclusions will be pointed out.

Based upon the foregoing information that you have heard today, the Federal Water Pollution Control Administration presents the following conclusions.

Number one: 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, in the Milwaukee River within Milwaukee County, in and downstream from the cities along the Grand River in Michigan, in the St. Joseph River in Indiana and Michigan; and in the streams of the Calumet Area of 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 in Wisconsin; at Chicago, Illinois; along the entire eastern shore of Lake Michigan, and near Manistique, Michigan. Short filter runs in water treatment plants have occurred at many locations including Green Bay, Sheboygan, and Milwaukee, in Wisconsin; Waukegan, Evanston, and Chicago, in Illinois; Gary and Michigan City, in Indiana; and Holland, Grand Rapids, Muskegon,Michigan,and Benton Harbor in

Indiana. Phosphate fertilizer concentrations now exceed critical algal growth values in many areas. Excessive sludgeworm populations indicating pollution of lake bed sediments occur near Manitowoc and Sheboygan in Wisconsin; from Port Washington, Wisconsin, to Waukegan, Illinois; and from 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 appreciable oxygen deficiency.

7. In addition to one existing nuclear power plant, five nuclear power plants, three of which will have double reactors, are proposed or under construction at Lake Michigan

sites for completion between 1970 and 1973. A special evaluation is desirable 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.

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 and may be toxic to fish and other aquatic life.

10. Disposal of polluted dredged material into the open water of Lake Michigan

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 contribute to deterioration of water quality.

11. Pesticide pollution or 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 provisions of the Federal Water Pollution Control Act.

That concludes the conclusions. I now go on to the recommended actions, which are divided into two parts, general recommendations and specific recommendations.

Under 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 applicable water quality standards.

2. Where a higher degree of treatment 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 three 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 and from the effect of siltation.

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 the 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, provisions be made in all planning for the maximum use of areawide sewerage facilities, and for discouraging the proliferation of small inefficient

treatment plants in contiguous urbanized areas, and for promoting 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 State 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 include: control of overproduction 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.

26. The treatment required by the above recommendations shall be provided and facilities placed in operation by no later than July 1972, unless the State water pollution control agencies require a lesser amount of time.

27. The conferees reconvene at least annually to assess progress.

This concludes the general

recommendations. I will now take up the specific recommendations, which consist of lists of known major sources of municipal and industrial wastes. These lists are included in the Report and were compiled from waste inventories provided by the State water pollution control agencies. I would at this time, Mr. Chairman, like to introduce this inventory into the record since the general recommendations do apply to all waste sources.

MR. STEIN: These lists will be included in the record. If the States, as they very well may have, have some changes bringing these up to date, this can be done. After working this out with the States in a constructive manner, we may have an up-to-date list for the record, because if we start amending the list in open conference we will be here through the night.

MR. SCHNEIDER: I was going to suggest that myself.

(Which said inventory is as follows:)

INVENTORY INFORMATION

WASTE SOURCES IN THE LAKE MICHIGAN BASIN

JANUARY 1968

APPENDIX		PAGE
B	Illinois Waste Sources	A-21
C	Indiana Waste Sources	A-27
D	Michigan Waste Sources	A-64
E	Wisconsin Waste Sources	A-142

NOTE: A complete inventory of Federal Installations is provided as an Appendix to "Water Pollution Problems of Lake Michigan and Tributaries -- Action for Clean Water", January 1968.

APPENDIX B
USDI - FWPCA
WASTE SOURCES: ILLINOIS
NORTH SHORE BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Highland Park, Ill.	25,532		municipal combined sewers						served by Cary Av., Park and Ravine plants of NSSD. primary and cl_2	L. Michigan
Lake Bluff, Ill.	3,494		municipal combined sewers	0.34					served by Lake Bluff plant of North Shore Sanitary District. primary (1922) chlorination (1962) Des. 0.28 mgd overloaded Pres. 0.34 mgd	L. Michigan
Lake Forest, Ill.	10,687		municipal combined sewers	1.2					served by Lake Forest plant of North Shore Sanitary District primary (1925) chlorination (1957) Des. 1.2 mgd	L. Michigan

APPENDIX B
USDI - FWPCA
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Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Lake Forest, Ill. (Contd.)									overloaded Pres. 1.2 mgd	
North Chicago, Ill.	22,938		municipal combined sewers	3.3					served by N. Chicago plant of North Shore Sanitary District secondary (1927) chlorination Des. 4.0 mgd Pres. 3.3	L.Michigan
Abbott Laboratories			BOD; COD; susp. Solids						activated sludge	L.Michigan
Waukegan, Ill.	55,719 (65,000 sewered)		municipal separate sewers	10.0					secondary (1942) chlorination Des. 10.5 mgd + 2.3 mgd primary Pres. 10.0 mgd	L.Michigan

APPENDIX B
USDI - FWPCA
WASTE SOURCES: ILLINOIS
NORTH SHORE BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Waukegan, Ill. (Contd.)										
Commonwealth Edison Company - Waukegan Plant			cooling water						None	L.Michigan
Outboard Marine Corp. Johnson Motors Div.			acids, cooling water						No information	L.Michigan
U. S. Steel Corp American Steel & Wire			sups. solids; oil; phenol; iron, acids						settling, acid reduction	L.Michigan
Winthrop Harbor, Ill.	3,848		municipal						served by Waukegan, Ill.	L.Michigan
Zion, Ill.	11,941		municipal						served by Waukegan, Ill.	L.Michigan

APPENDIX B
USDI - FWPCA
WASTE SOURCES: ILLINOIS
CHICAGO - CALUMET RIVER

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Columbia Yacht Club			sanitary						settling tank chlorination	L.Michigan
U. S. Steel Corp. South Works			sanitary-oils,BOD, susp.solids,iron, phenol, acids						sanitary-MSD thickeners for blast furnace dust & oil skimmers	L.Michigan Calumet Riv.
Allied Chemical Co.			cooling water						None	Calumet Riv.
Bulk Terminals			sanitary and oils						sanitary-package aeration plant industrial-oil separator	Calumet Riv.
Commonwealth Edison Co.			cooling water						None	Calumet Riv.
Ford Motor Company			spray booth wash cooling, chromate						paint-chemical treatment wastes to MSD after sedimentation and pH control	Calumet Riv.

APPENDIX B
USDI - FWPCA
WASTE SOURCES: ILLINOIS
CHICAGO - CALUMET RIVER

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
General Mills			cooling water						cooling water-none indust.& sanitary to MSD	Calumet R.
Great Lakes Carbon			cooling water						None	Calumet R.
Interlake Steel			susp.solids, BOD, phenol, ammonia, cyanides						Sanitary-MSD Indust.-coagulation & sedimentation; ammonia, phenols and cyanides to MSD	Calumet R.
International Harvester (Wisconsin Steel)			susp.solids,BOD, iron, phenol, ammonia, acids,oil, cyanides						sanitary-MSD indust.-thickeners,oil skimmers,cooling towers, recirculation system for all process waters due to be completed July 1968	Calumet R.

APPENDIX B
USDI - FWPCA
WASTE SOURCES: ILLINOIS
CHICAGO - CALUMET RIVER

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Republic Steel Co.			susp.solids, BOD, acids, phenol, ammonia, oil and cyanides						sanitary-MSD indust.- sedimentation, oil recovery, pickling liquor to offsite dump; chemical treatment for coke plant wastes before discharge to MSD	Calumet R.
Valley Mould			suspended solids						settling basin	Calumet R.

APPENDIX C

USDI - FWPCA

WASTE SOURCES: INDIANA

LITTLE CALUMET-GRAND CALUMET RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Baileytown (Porter)										
Northern Indiana Public Service Co.			cooling water						septic tank & absorption for sewage; ash lagoon absorption	L.Michigan
Chesterton, Ind.	4335		municipal combined sewers	1.06					activated sludge(1963) chlorination Des 1.50 mgd Pres 1.06 mgd	Coffee Cr. to Little Calumet R.
Bethlehem Steel Corp.			sanitary - iron,phenol, oil,NH_3,acids						sanitary - activated sludge;industrial - settling tanks & lagoons for solids; deep well disposal	L.Michigan

APPENDIX C
USDI - FWPCA
WASTE SOURCES: INDIANA

LITTLE CALUMET-GRAND CALUMET RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Crown Point, Ind.	8443		municipal combined sewers	0.9					trickling filter(old) activated sludge(1966) chlorination Des 1.8 mgd Pres 0.9 mgd	Beaver Dam Ditch Deep River
E. Chicago, Ind.	57,669		municipal combined sewers	11.5					activated sludge(1960) chlorination Des 20 mgd Pres 11.5 mgd	G.Cal.R.-Ind.Harb. Canal-L. Michigan
American Steel Foundries				.5					sanitary - E. Chi.S.D. .5 mgd industrial - settling basin	Ind.Harbor Canal

APPENDIX C
USDI - FWPCA
WASTE SOURCES: INDIANA
LITTLE CALUMET-GRAND CALUMET RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
E. Chicago, Ind.(Cont.)										
Blaw-Knox			suspended solids, oil						sanitary - E.Chi.S.D. industrial wastes - settling tank & filter	Ind.Harbor Canal

The Company has completed its waste control program and is now providing adequate waste control. The following projects have been completed: insulation of the clarifloculator, installation of continuous sludge removal facilities on the clarifloculator, connection of roll grinder coolant waste flow to the East Chicago Sanitary District's sewerage system, and installation of a new wet dust collector on the No. 1 sand system. Consistent with the State's policy requiring adequate waste treatment or control facilities for new process operations, filtration equipment will be installed to handle wastes from a new roll grinder. The effluent monitoring program has been expanded to provide satisfactory data on all outfalls.

Cities Service Petroleum Co.			BOD, oil,phenol, ammonia	92					sanitary - E.Chi. G.Calumet R. S.D. 92 mgd; industrial wastes - oil separation tanks ammonia-sulfide strippers; separate disposal of waste caustic & acids	

APPENDIX C
USDI - FWPCA
WASTE SOURCES: INDIANA
LITTLE CALUMET-GRAND CALUMET RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
E. Chicago, Ind.(Cont.)										
Cudahy Packing Co.			No data available							
E. I. Dupont De Nemours & Co.			sulphates,clorides, susp.solids, zinc acid						sanitary - E.Chi.S.D. industrial - acid neutralization settling & controlled discharge	G.Calumet R.
General American Transportation			oil; susp.solids						all wastes to E.Chi.S.D. after pretreatment	
Inland Steel Company (next page)										

APPENDIX C
USDI - FWPCA
WASTE SOURCES: INDIANA
LITTLE CALUMET-GRAND CALUMET RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
E. Chicago, Ind.(Cont.)										
Inland Steel Company			sanitary, susp. solids,oil,phenols, cyanides,acids						sanitary - 3 trickling filters w/chlorination; industrial - coke plant cooling; water recirc.;phenol extraction, naphthalene recovery; ammonia to E.Chi.S.D. scale pits; oil separator; flue dust thickeners; chemical clarification	Ind.Harbor & L. Michigan

Final plans for the waste treatment facilities for the Plant No. 2 and No. 3 Coke Plant, and Plant No. 2 and No. 3 Blast Furnace Areas were approved on June 20, 1967. The plans for the terminal solids clarification and oil skimming facilities for treatment of wastes from nine Plant No. 2 sewers were approved on August 15, 1967. The facilities proposed are as follows:

APPENDIX C
USDI - FWPCA
WASTE SOURCES: INDIANA
LITTLE CALUMET-GRAND CALUMET RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters

E. Chicago, Ind.(Cont.)

Inland Steel Company (cont.)

Plant No. 2 and No. 3 Coke Plant Areas

The Company will provide additional in-plant controls and permanent facilities to convey ammonia still wastes and other plant wastes to the East Chicago Sanitary District's sewerage system. The permanent facilities will be completed by October 1, 1967. The ammonia still wastes are currently being discharged to the East Chicago Sanitary District's sewerage system through temporary pumping facilities. Additional settling basins and recirculation pumps will be installed at the Coke Quenching Station. These facilities are to be completed during 1968.

Plant No. 2 and No. 3 Blast Furnace Areas

The Company will provide additional in-plant controls and construction of secondary flue dust settling basins. The facilities are to be completed during 1968.

Terminal Treatment Plant

The plans require construction of primary and secondary solids removal facilities and oil skimming basins, solids handling facilities and oil dewatering and storage facilities for treatment of 140,000 gpm of wastewater from nine Plant No. 2 sewers. The facilities are to be completed in May, 1970.

The Company is in the process of letting bids for construction of waste treatment facilities for the new 12-inch Merchant Mill that were approved by the State on March 21, 1967. The deep well disposal system approved by the State on February 21, 1967, is under construction. The Merchant Mill waste treatment facilities will be completed by December 31, 1968, and the deep well system will be completed by June 30, 1968. Construction has been completed on the additions to the North End Lagoon that were approved by the State on February 3, 1966.

The Company has an adequate effluent monitoring program. Completion of the facilities proposed by the Company should provide adequate waste control.

APPENDIX C
USDI - FWPCA
WASTE SOURCES: INDIANA

LITTLE CALUMET-GRAND CALUMET RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
E. Chicago, Ind.(Cont.)										
Mobil oil Co.			oil,ammonia,BOD, COD,phenols	2.5					sanitary - E. Chi.S.D. 2.5 mgd; industrial wastes - oil separators, ammonia-sulfide stripper, in-plant control, separate disposal of waste caustics & acids	Ind.Harbor Canal
Purex Co.			no data available							
Sinclair Refining Co.			oil; ammonia; BOD; COD; susp.solids; phenols	5.5					sanitary - E. Chi.S.D. 5.5 mgd; industrial wastes - oil separators, ammonia-sulfide stripper, in-plant control & separate disposal of waste caustics & acids	Ind.Harbor Canal

APPENDIX C

USDI - FWPCA

WASTE SOURCES: INDIANA

LITTLE CALUMET-GRAND CALUMET RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
E. Chicago, Ind.(Cont.)										
Sinclair Refining Co.(cont.) On July 18, 1967, the State approved final plans for construction of sewers, sump pumps, and force mains to convey water drawoff from storage tanks in the north and south tank farm to the Ballast Oil Separation Tanks, a sludge dewatering tank to handle water treatment sludges, and two 55,000-barrel storage tanks and pumping station to pump and store stormwater flow that exceeds the design capacity of the API oil separator, for later treatment through the oil separation facilities. The Company is preparing plans and specifications for a presettling tank equipped with mechanical sludge and oil skimming equipment for installation ahead of the API oil separator. The proposed projects will be completed by December 31, 1968. Studies are being made relative to secondary treatment of the wastewater. The Company will be required to provide additional reductions in BOD, oils, and threshold odor-producing substances.										
Union Carbide (Linde Division)			chromates, susp. solids, oil	.25					Sanitary - E. Chi.S.D. .25 mgd; industrial wastes - settling ponds and oil separation	Ind.Harbor Canal

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WASTE SOURCES: INDIANA

LITTLE CALUMET-GRAND CALUMET RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
E. Chicago, Ind. (Cont.)										
U. S. Gypsum			suspended solids	4.5					sanitary - E. Chi.S.D. 4.5 mgd; industrial wastes - settling basin & saveall clarifiers	Ind.Harbor Canal
U. S. Lead Refinery									only cooling water is discharged	Ind.Harbor Canal
Youngstown Sheet & Tube Co.			sanitary - susp. solids;phenols; acids;cyanide;oils						sanitary - E.Chi.SD industrial - scale pits; oil separators; phenol extraction;naphthalene recovery;flue dust thickeners;disposal of waste pickle liquor & halogen line solutions on slag fill & lagoon	Ind. Harbor Canal; Lake Michigan

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USDI - FWPCA
WASTE SOURCES: INDIANA
LITTLE CALUMET-GRAND CALUMET RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
East Chicago, Ind.(Cont.)										
Youngstown Sheet & Tube Co. (Cont.)										

On July 19, 1967, final plans and specifications for waste treatment facilities for the No. 1 Tin Mill, No. 2 Open Hearth, and No. 3 Hot Strip Mill were approved by the State. The plans propose the following:

Coke Plant

The Company has completed construction of naphthalene scrubbers in the Coke Plant and connection of contaminated wastes from the Coke Plant to the East Chicago Sanitary District's sewerage system.

No. 2 Open Hearth

Construction of clarification and sludge handling facilities for treatment and reuse of 11,440 gpm of gas wash water and cooling towers to cool and reuse 14,580 gpm of gas cooling water. The facilities are to be completed by the end of 1967.

No. 1 Tin Mill - Waste Pickle Liquor System

Construction of sewers, sumps, pumps, and storage tanks to collect and store waste pickle liquor for subsequent haulage by tank truck for disposal on a hot slag fill. The facilities are to be completed by October 1, 1967.

No. 3 Hot Strip Mill

Construction of primary oil and solids removal facilities, chemical flocculation and clarification, and sludge handling facilities for treatment of 3,000 gpm of oily wastes, primary and secondary scale pits for treatment of 9,600 gpm of roughing stand wastewater and 51,000 gpm of finishing stand wastewater, and pressure filters for filtration of the total wastewater flow. The facilities are to be completed during the first quarter of 1968.

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WASTE SOURCES: INDIANA

LITTLE CALUMET-GRAND CALUMET RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
East Chicago, Ind.(Cont.)										
Youngstown Sheet & Tube Co. (cont.)										

Final plans for the Buttweld Mill were due during 1967 and final plans for the Blast Furnace recirculation system are progressing satisfactorily. The projects in the No. 1 Tin Mill, No. 2 Tin Mill, and Cold Reduced Sheet Mill are interceptor sewers to collect oil and additional work is required to prepare final plans for these sewers.

The North Lagoon will treat the effluent from the No. 3 Hot Strip Mill waste treatment facilities and the effluent from the No. 5 Stand of the Tandem Rolling Mill in the No. 3 Cold Reduced Sheet Mill.

The Company's proposed waste treatment facilities should provide adequate waste control. The Company is maintaining an adequate effluent monitoring program.

East Gary, Ind.	9369		municipal combined sewers	1.0					trickling filter chlorination(1960) Des 1.3 mgd Pres 1.0 mgd	Burns Ditch L. Michigan

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WASTE SOURCES: INDIANA
LITTLE CALUMET-GRAND CALUMET RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Gary, Ind.	178,320	174,500	municipal combined sewers	42.5					activated sludge chlorination Des 60 mgd + 20 mgd prim. Pres 42.5 mgd	G.Cal.River L.Michigan
American Bridge Div.			cooling water						none	G. Cal.River L.Michigan
Berry Refining Co.			closed						use of facilities by scavenging firm for waste disposal proposed	
Gary Steel Works			NH_3;CN:solids, BOD;acids						sewage - Gary S.D. indust. - scale pits; flue dust thickeners; settling basins; seepage lagoon	G.Cal.River L.Michigan

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USDI - FWPCA
WASTE SOURCES: INDIANA

LITTLE CALUMET-GRAND CALUMET RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Gary, Ind. (Cont.)										
Georgia Pacific Co. (Steiner Tissue)			domestic; susp. solids;BOD(fibers)						sewage - Gary S.D. indust. - savealls	G. Cal.River L.Michigan
National Tube Div. Gary			pickle liquor; solids; oil						none	G. Cal.River L.Michigan
Northern Ind.Pub. Service Co.			440 mgd cooling water; domestic						domestic-septic tank subsurface sand filter; indust.-flyash & bottom ash lagoons	L.Michigan
Universal Atlas Cement Co.			solids; oil						trickling filter(1928); oil separation	L.Michigan

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WASTE SOURCES: INDIANA

LITTLE CALUMET-GRAND CALUMET RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD5	Raw SS	Discharge BOD5	Discharge SS	Treatment Provided	Receiving Waters
Gary, Ind. (Cont.)										
U. S. Steel Gary Sheet & Tin Mill			oils; solids; acids						sewage - Gary SD: indust.- scale pits; pickle liquor absorption lagoon; oil separators	G. Cal.Riv. L. Michigan
Vulcan Detinning Co.			caustics, solids						sewage - septic tank; indust. - spent caustic sold	G. Cal.Riv.
Griffith, Ind.	9483		municipal combined sewers						to Hammond San. Dist.	Cady Marsh Ditch; L.Cal. River; Burns Ditch
American Chemicals Co.									sewage - septic tank indust. - lagoons	Turkey Creek

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WASTE SOURCES: INDIANA

LITTLE CALUMET-GRAND CALUMET RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Hammond, Ind.	111,698	132,000	municipal combined sewers	35.1					activated sludge 1964 Des 36 mgd Pres 35.1 mgd	G. Cal River 2/3 to L.Mich. 1/3 to Ill.Riv. Basin
Also serves:										
Griffith, Ind.	9483									
Highland, Ind.	16,284									
Munster, Ind.	10,313									
Whiting, Ind.	8,137									
American Maize Prod. Co.			BOD, solids						sewage to Hammond S.D. aerated lagoons; water recirculation; chlorination	L. Michigan
Calumet Nitrogen Prod.			NH_3; chromium						sewage to Hammond S.D. indust.-settling pond	Ind. Harbor Canal

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WASTE SOURCES: INDIANA

LITTLE CALUMET-GRAND CALUMET RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Hammond, Ind. (Cont.)										
Commonwealth Edison Company			cooling water 1000 mgd						sewage - HammondL.Michigan SD; indust. - fly ash and bottom ash settling basins	
Federal Cement Tile Co.			acids							
Lever Brothers Co.			detergents; BOD; oils; susp.solids						recirculation; cooling towers	Wolf Lake
Highland, Ind.	16,284	8200	municipal combined sewers						Hammond S.D.	Gr.Cal.Riv.
Hobart, Ind.	18,680	9800	municipal combined sewers	1.3					activated sludge 1962 chlorination Des 2.0 mgd Pres 1.3 mgd	Deep River Burns Ditch

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WASTE SOURCES: INDIANA

LITTLE CALUMET-GRAND CALUMET RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Munster, Ind.	10,313		municipal combined sewers						served by Hammond S. D.	G. Cal.River
Portage Twp, Ind.	11,822									
Air Reduction & Chem. Company			no data							
Midwest Steel Div. Nat. Steel Corp.			cyanide; oils; phenols; solids; acids						cyanide isolation; deep well disposal; settling tanks	Burns Ditch
Porter, Ind.	2189		municipal combined sewers						none - under order by Stream Pollution Control Board; referred to Attorney General	L.Calumet R.

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WASTE SOURCES: INDIANA

LITTLE CALUMET-GRAND CALUMET RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Valparaiso, Ind.	15,227		municipal combined sewers	2.35					activated sludge(1954) chlorination (overloaded) Des 2.0 mgd Pres 2.35 mgd	Salt Creek L.Cal.River L. Michigan
Vale City Packing Co.			meat packing						septic tank absorption	
Indiana Gen. Corp.			metals						septic tank settling basin	
Whiting, Ind.	8137		municipal combined sewers						served by Hammond S.D.	combined overflow direct to Lake Michigan
American Oil Co			oils; NH_3; phenol; sulfides; BOD						sewage to Whiting sewers; indust.-sour water stripper; oil separation; aerated lagoons	L.Michigan & Ind.Harb. Canal

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WASTE SOURCES: INDIANA

LITTLE CALUMET-GRAND CALUMET RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Whiting, Ind. (Cont.)										
Union Carbide Chemical			oil; BOD; susp. solids; polyethylene pellets						sewage to Whiting sewers & E. Chi. S.D. indust.- oil separators, settling basin; in-plant control; polyethylene pellets collected	L.Michigan & Ind.Harb. Canal
Union Tank Car Co.			oil; BOD; solids						sewage - to Hammond SD indust - oil separation, Hammond SD	Ind. Harbor Canal

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WASTE SOURCES: INDIANA

LAKE MICHIGAN SHORE

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Ogden Dunes	947		municipal						septic tanks	L.Michigan
Michigan City,Ind.	36,653		Municipal-combined sewers	12					activated sludge 1956 chlorination Des 10 mgd (overloaded) Pres.12 mgd expansion to 15 mgd under way; completion due 1968	Trail Cr. Lake Mich.
American Cyanimid Co.			susp. solids						septic tank & absorption settling & deep well disposal	Trail Cr.
Great Lakes Dressing Plant			meat packing						ridge & furrow irrigation; septic tank & absorption for sewage	Trail Cr.

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WASTE SOURCES: INDIANA

LAKE MICHIGAN SHORE

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Michigan City, Ind. (Contd.)										
Northern Indiana Pub. Service Co.			cooling water						septic tank & absorption for sewage; ash settling pond	L.Mich.
Phillips Drill Co.			oil; susp.solids						septic tank & absorption for sewage; oil separator	Trail Cr.
Royal Metal Co.			cyanides; oil						activated sludge for sewage; ion exchange; settling tank & lagoon	Trail Cr

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WASTE SOURCES: INDIANA

ST. JOSEPH RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Albion, Ind.	1325		municipal combined sewers						lagoons being built; due 1968-0.15 mgd	Elkhart Riv.
Angola, Ind.	4725		municipal combined sewers	0.8					trickling filter chlorination(1963) Des 0.85 mgd Pres 0.8 mgd	Lakes - Pigeon Riv.
Weatherhead Co.			cyanide; oil; chrome						cyanide control; oil separation; ion exchange; chromium reduction	
Angola Reduction Co.			rendering wastes						grease trap and septic tank	Silver Lake
Ardmore, Ind.	2500								septic tanks	

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WASTE SOURCES: INDIANA

ST. JOSEPH RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Ashley, Ind.	721		municipal combined sewers	0.05(est)					activated sludge; tertiary lagoon (1965) Des 0.08 mgd Pres 0.05 mgd(est)	Turkey Cr. Pigeon Riv.
Benton, Ind.	250								septic tanks	
Brimfield, Ind.	200								septic tanks	
Bristol, Ind.	991		no sewer system						septic tanks	
Bristol Band Instrument Co.			cyanide; heavy metals						cyanide control; soil absorption	St. Joseph River

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WASTE SOURCES: INDIANA

ST. JOSEPH RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste(lbs/day) Raw BOD_5	Waste(lbs/day) Raw SS	Waste(lbs/day) Discharge BOD_5	Waste(lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Cromwell, Ind.	451		municipal combined sewers						none	L.Wawasee; Trukey Cr.; Elkhart R.
De Wart Lake, Ind.	2000								septic tanks	
Dunlap, Ind.	115 (no data)									
Elkhart, Ind.	40,274	30,255	municipal combined sewers	12					primary; chlorination (1955) Des 12 mgd Pres 12 mgd	St.Joseph R.
American Coating Mills			sulphite paper							

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ST. JOSEPH RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Elkhart, Ind. (Contd.)										
Continental Can Co.			BOD; susp.solids; color						bar screen and air flotation; some construction planned has been approved by state	Elkhart R.
County Fertilizer			rendering wastes						septic tank - sludge lagoon	
Elkhart Packing Co.			meat packing						grease separation; blood collection lagoon; maintenance poor	
J. Whisler & Sons			meat packing						fine screens, blood collection; grease separation; soil absorption ponds	Yellow Cr.

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WASTE SOURCES: INDIANA

ST. JOSEPH RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Elkhart, Ind.(Contd.)										
Hart Metal-Glass Prod. Co.			chrome; cyanide; heavy metals							
N.Y.C.R.R. Yard			oils						oil separator; soil absorption ponds	Honey Cr.
Foraker, Ind.	100								septic tanks	
Fremont, Ind.	937		municipal	0.12					trickling filter chlorination (1958) Des 0.15 mgd Pres 0.12 mgd	Crooked Cr. Fawn River

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ST. JOSEPH RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Goshen, Ind.	13,718	13,000	municipal combined sewers	2.40					activated sludge(1963) Des 3.50 mgd Pres 2.40 mgd	Elkhart R.
Artco Metal Finishing			cyanide; chrome						cyanide control	
Barler, Inc.			caustic soda solution							
Chase Bag Co.			dyes							
Hess Canning Co.			(tomatoes)						lagoon storage until winter	
Penn Electrical Switch Co.			cyanide;heavy metals						cyanide control settling tank	Rock Run
Pine Manor, Inc.			poultry						grease separation; blood collection; soil absorption ponds	

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ST. JOSEPH RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Granger, Ind.	125								septic tanks	
Helmer, Ind.	110								septic tanks	
Howe, Ind.	550								septic tanks	
Hudson, Ind.	428								septic tanks	
Kendallville, Ind.	6765		municipal combined sewers	1.40					chlorination trickling filter(1958) Des 1.44 mgd Pres 1.40 mgd	lakes, Sylvan Cr. Elkhart R.
Kendallville Fertilizer Co.			rendering solids						septic tanks; lagoon	Henderson Cr.

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ST. JOSEPH RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Kendallville, Ind. (Contd.)										
Sorenson Foundry			domestic(500 people)						lagoon proposal approved by state 9/22/64	
McCray Refrigerator Co.			phosphates							
Kimmel, Ind.	350								septic tanks	
La Grange, Ind.	1990		municipal combined sewers	0.185					trickling filters(1958) Des 0.38 mgd Pres 0.185 mgd	Fly Cr. - Pigeon R. St.Joseph R.
Gordon Baking Co.			milk wastes							Fly Creek
Lake James, Ind.	3000								septic tanks	

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Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Ligonier, Ind.	2595		municipal combined sewers	0.25					primary(1941) Des 0.20 mgd Pres 0.25 mgd	Elkhart Riv.
Springer Corp.			oils							
Middlebury, Ind.	917		municipal						septic tanks	
Middlebury Coop.Creamery			BOD; susp.solids						septic tanks; broad irrigation	Little Elkhart Riv.
Milford, Ind.	197								septic tanks	
Maple Leaf Farms Processing Plant			poultry						septic tanks; soil absorption	
Cecil Foods, Inc.			canning						septic tank; soil absorption	

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ST. JOSEPH RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Milford, Ind. (Cont.)										
Price Duck Farms			duck raising							Turkey Cr.
Slabaugh Duck Farms			" "							Turkey Cr.
Wentzel Feed Co.			duck feeding						severe problem reported	
Milford Junction, Ind.	1167		municipal						none; secondary plant to be completed 1969	Turkey Cr. Elkhart R.
Millersburg, Ind.	489								septic tanks	

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ST. JOSEPH RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Mishawaka, Ind.	33,360	34,000	municipal combined sewers	9.00					activated sludge(1952) chlorination (1966) Res 8.30 mgd Pres 9.00 mgd	St.Joseph R.
Kamm & Schellinger			malt liquor						none	St.Joseph R.
U.S. Rubber Co.			rubber						primary settling chem. flocculation vacuum filter	" " "
Volney Felt Mills			rag pulp & paper						municipal sewer system	St.Joseph R.
Rockwell Standard Corp.			chrome						acid neutralization; sludge lagoon; chemical flocculation settling	St.Joseph R.

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ST. JOSEPH RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Mishawaka, Ind. (Cont.)										
Indiana-Michigan Electric Co.			domestic cooling water						septic tank; absorption system; ash settling ponds	St.Joseph R.
Jontz Mfg. Co.			cyanide						septic tank soil absorption; cyanide isolation	St.Joseph R.
Mongo, Ind.	225								septic tanks	
Napanee, Ind.	3895		municipal combined sewers	0.70					activated sludge(1963) chlorination Des 0.90 mgd Pres 0.70 mgd	Burlincourt Ditch; Turkey Creek

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Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
New Carlisle, Ind.	1376								septic tank	
Animal By-Products Corp.			rendering						septic tank; soil absorption	
Harbison Carborundum			cutting & grinding						settling basin; absorption lagoon	
New Paris, Ind.	900		municipal sewer system exists, extent unknown						septic tanks	Turkey Cr.
New Paris Creamery			BOD; susp.solids						septic tank; absorption	Turkey Cr.
Polo Produce, Inc. Land O'Goshen Plant			meat packing						fine screens; blood collection; grease separation; soil absorption; septic tank	
Torman Poultry			poultry						none - wastes to sewer system	

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WASTE SOURCES: INDIANA
ST. JOSEPH RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Notre Dame U. St. Mary's College		(no data)								
Orland, Ind.	424								septic tanks	
Osceola, Ind.	1350								septic tanks	
Pleasant Lake, Ind.	600								septic tanks	
South Milford, Ind.	350								septic tanks	
Stroh, Ind.	475								septic tanks	

APPENDIX C
USDI - FWPCA
WASTE SOURCES: INDIANA

ST. JOSEPH RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Syracuse, Ind.	1595		municipal combined sewers	20					trickling filter(1962) chlorination Des 0.25 mgd Pres 0.20 mgd	Turkey Cr. Elkhart R.
Weatherhead Corp.			cyanide; heavy metals						Cn isolation & destruction	Turkey Cr.
Red Cedar Poultry Processing			poultry							
Vylactose Labs.										
W. A. Jones Poultry Plant			poultry							
Topeka, Ind.	600		municipal combined sewers						none	Little Elkhart R.

APPENDIX C

USDI - FWPCA
WASTE SOURCES: INDIANA

ST. JOSEPH RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Wakarusa, Ind.	1145		municipal combined sewers						none	Baugo Cr. St.Joseph R.
Lehman Veal & Poultry Packers			meat packing							
Waterford Mills, Ind.	150								septic tanks	
Wawaka, Ind.	300								septic tanks	
Wawasee Lake, Ind.	500								septic tanks	
Wolcottville, Ind.	720								none - system being planned	
Wolf Lake, Ind.	375								septic tanks	

APPENDIX D
USDI - FWPCA
WASTE SOURCES: Michigan

St. Joseph River Basin

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD5	Raw SS	Discharge BOD5	Discharge SS	Treatment Provided	Receiving Waters
Benton Harbor	19,136	43,500		5.51	11300	8900	595	1010	Act. Slud.	St. Joseph R.
Clark Equip. Co.			Cooling Water	.050						Ox Creek
Midwest Timer Service, Inc.			Cyanide, Chromium	.005					Sep. Tank	Pratt Creek
Benton Heights	6,122									
Benton Township	15,171									
Berrien Springs	1,953			0.16	160	347	101	110	Primary	
Pearl Grange Packing Co.				0.025			300		Sep. Tank Lagoon and Spray Irrigation	
Stover Soft Water Serv.				Flow restricted to 50 gpm and 6000 pounds per day NaCl						St. Joseph R.
Bertrand	3,500									

APPENDIX D
USDI - FWPCA
WASTE SOURCES: Michigan

St. Joseph River Basin

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Raw SS	Discharge BOD_5	Discharge SS	Treatment Provided	Receiving Waters
Bronson	2,267	2,250		6.80	11600	12700	1700	3120	Filter	St. Joseph R.
Kingston Prod. Corp. (Douglas Mfg. Div.)			Cyanide	0.158			100		Chemical ttmt of plating water	Swan Creek
Bronson Mfg. Plating Co.			Cyanide, metals	0.03						Swan Creek
Buchanan	5,341			0.78	617	800	403	344	Primary	
Clark Equip. Co.			Oils	0.1			380		Oil traps	McCoy Creek
Cassopolis	2,027	1,950							Spray irrigation	Stone Lake
Centerville	971									
Coldwater	8,880	8,800		0.311	800	890	34	36	Act. Slud.	St. Joseph R.
Municipal Power Plant			Cooling water	0 .18						
Coloma	1,473			0.25	475	319	294	190	Primary	Paw Paw R.
Coloma Co-Op Canning Co.				0.36			2970		Spray irrigation and lagoons	Paw Paw R.

APPENDIX D
USDI - FWPCA
WASTE SOURCES: Michigan

St. Joseph River Basin

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Raw SS	Discharge BOD_5	Discharge SS	Treatment Provided	Receiving Waters
Colon	1,055			0.25	475	319	294	190	Primary	Paw Paw R.
Constantine	1,710			0.15	593	342	244	151	Primary	
Decatur	1,827									
Dowagiac	7,208			1.25	1430	1655	1042	656	Primary	
Rudy Mfg. Co.				0.4			50		Stabilization ponds with chemical ttmt	
Eau Claire	562									
Michigan Tube Co.			CN, Cr, Zn	0.096			50	195	Sep. Tank, chem. ttmt, aeration, sedimentation	
Silver Mill Frozen Foods			BOD, SS	0.288			200		Septic tank, irrigation, screens	Farmers Creek
Edwardsburg	902									
Gobles	816									

APPENDIX D
USDI - FWPCA
WASTE SOURCES: Michigan

St. Joseph River Basin

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD5	Raw SS	Discharge BOD5	Discharge SS	Treatment Provided	Receiving Waters
Hartford	2,305	2,250		0.13	161	351	105	205	Primary Chemical ttmt and settling	Paw Paw R.
Hartford Metal Protection Co.			Cr, Cn, CN, Ni	0.07				114		
Hillsdale	7,629	10,900		1.2	1600	2120	300	430	Trickling filter	St. Joseph R.
Jonesville	1,896	1,200								
Kinderhook										
Lawrence	773	1,000								
Burnette Farms				0.05			300		Septic tank spray irrigation	Brush Creek
Lawton	1,402									
Welch Grape Juice			Food products	0.8			1000		Screen and spray irrigation	Groundwater
Honee Bear Canning Co.									Septic tank lagoon	Paw Paw R.

APPENDIX D
USDI - FWPCA
WASTE SOURCES: Michigan

St. Joseph River Basin

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Raw SS	Discharge BOD_5	Discharge SS	Treatment Provided	Receiving Waters
Litchfield	993									
Marcellus	1,073									
Mattawan	400									
Glaser-Crandell Co.				0.08			2000		Sep tank and lagoon	Groundwater
Milburg										
Milburg Fruit Exchange				0.144			41	36	Sep. tank oxidation lagoons	Blue Cr.
New Buffalo	2,128	1,950		3.03	5812	6242	2325	5837	Act. Slud.	
Niles	13,842			2.89	2241	4266	1133	1663	Primary	
French Paper Co.			SS	0.8			2870	3620	Flotation save-alls	St. Joseph R.
Kawneer Co.			Chrome wastes	0.6			50		SO_2 tmt sep. tank	St. Joseph R.
Michigan Mushroom Co.			Food process wastes	0.025			200		Vibrating screens	St. Joseph R.

APPENDIX D
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WASTE SOURCES: Michigan

St. Joseph River Basin

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD5	Raw SS	Discharge BOD5	Discharge SS	Treatment Provided	Receiving Waters
Schmidt Packing Co.			SS and BOD	0.1			67		Grease traps, collection of paunch manure and bones	Dowagiac R.
Simplicity Pattern Co.			Fibers	1.18			1350	2360	Save-all city sewer	St. Joseph R.
Paw Paw	2,970	2,500		0.579	1393	1610	1138	569	Primary	Paw Paw R.
A. F. Murch Co.				0.72			300		Sep. tank spray irrigation	Paw Paw R.
Pet Milk Co.				0.10			740	335	Sep. tank spray irrigation	Paw Paw R.
Quincy	1,602	1,550		0.10	125	450	64	63	Primary	St. Joseph R.
Quincy Products Co.			CN, Cr, Cu, Zn	0.056			50	74	Chemical	Marble Lake
Saint Joseph	11,755	11,500								
Industrial Rubber Goods			Cooling water						Sep. tank chlorination	Abraham Dr.
Pet Milk Co.				3.69					Discharges to city sewer	

APPENDIX D
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WASTE SOURCES: MICHIGAN

ST. JOSEPH RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD5	Raw SS	Discharge BOD5	Discharge SS	Treatment Provided	Receiving Waters
Scottdale										
Sodus	250									
Sodus Fruit Exchange				0.500			300		Sep. tank screen spray irrigation	Pipestone Creek
Stevensville	697									
Sturgis	8915	8500		1.05	2310	3395	342	543	Filter	St. Joseph R.
Sumnerville	225									
Tekonsha	744									
Three Rivers	7092			1.29	1298	1463	635	646	Primary	
Union City	1669								Lagoon	St. Joseph R.
Schafer Mfg. Co.				0.08			50			St. Joseph R.

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WASTE SOURCES: MICHIGAN

ST. JOSEPH RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD5	Raw SS	Discharge BOD5	Discharge SS	Treatment Provided	Receiving Waters
Vicksburg	2224	2200							Filter	St. Joseph R.
Simpson Lee Paper Co.				3.9			3025	4557	Sedimentation with coagulation	Goardneck Creek
Watervliet	1818	1500								Paw Paw R.
Watervliet Paper Co.			SS	2.6			6500	10281	Settling and chemical recovery	Paw Paw R.
White Pigeon	1399									
Weyerhauser Paper Co.			SS	4.6			3765	7849	Floatation save-all clarifier	White Pigeon Creek

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WASTE SOURCES: MICHIGAN

BLACK RIVER BASIN (SOUTH)

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD5	Raw SS	Discharge BOD5	Discharge SS	Treatment Provided	Receiving Waters
Bangor	2,109									
DuWel Decorative Company			Cr^3 90 ppm Ni 1 ppm pH 3.8	0.288				122	Sep. Tank Sedimentation & Chrome Destruction	Black River
Bloomingdale	471									
Breedsville	245									
Grand Junction	300									
Lacota	135									
Pullman	200									
Saddle Lake	200									
South Haven	6,149	6,500			2400		1300		Primary	Black River
Michigan Fruit Canners, Inc.				0.447			2316	403	City Sewer Screen	Black River
South Haven Chemical Co.				0.050						Black River
South Haven Muni. Power Plant			Heat						None	L. Michigan

APPENDIX D
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WASTE SOURCES: MICHIGAN

KALAMAZOO RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Raw SS	Discharge BOD_5	Discharge SS	Treatment Provided	Receiving Waters
Albion	12,749			2.22	2160	2295	1425	1220	Primary	Kalamazoo R.
Allegan	4,822								Primary	Kalamazoo R.
Rockwell Standard Corp.									city sewer oil skimmer	Kalamazoo R.
Battle Creek	44,169			10.7	34400	41800	8750	5180	Trickling Filter	Kalamazoo R.
Culligan Soft Water, Inc.				.006					city sewer controlled discharge	Kalamazoo R.
Grand Trunk RR Car Shop			pH 7.8 - 8.6	0.4					city sewer oil separation	Battle Ck.
Michigan Carton Company				2.4			1045	1040	city, Bird save-all, Waco filter all waste to city sewers	Kalamazoo R.
Bentheim	100									
DeKleine Packing Co.									septic tank screen	Black Ck. to Big Rabbitt R.

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WASTE SOURCES: MICHIGAN

KALAMAZOO RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Raw SS	Discharge BOD_5	Discharge SS	Treatment Provided	Receiving Waters
Burnips	250									
Hudsonville Creamery										Rabbitt R.
Calhoun County										
Consumers Power Company										Battle Ck.
Charlotte	7,657			0.55	1368	950	197	532	Trickling filter	Battle Ck.
Comstock	2,500									
Concord	990									
Devereaux										
Douglas	602									
Douglas Food Industries of America									septic tank, screen	Kalamazoo R.

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WASTE SOURCES: MICHIGAN

KALAMAZOO RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD5	Raw SS	Discharge BOD5	Discharge SS	Treatment Provided	Receiving Waters
East Saugatuck										
Lortin Products			Irrigation May to Nov. direct discharge rest of year.	0.05					septic tank settling irrigation	Kalamazoo R.
Fennville	705									
Michigan Fruit Canners, Inc.			S.V.S. 366	0.5			2300	403	part. irrigation discharge cooling	Mann Ck.
Fillmore										
Galesburg	1,410									
New York Airbrake Co.				0.2					Trickling filter, floatation, oil skimming	Kalamazoo R.
Hamilton	700									

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WASTE SOURCES: MICHIGAN

KALAMAZOO RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD5	Raw SS	Discharge BOD5	Discharge SS	Treatment Provided	Receiving Waters
Homer	1,629			0.07	1920	4380	948	1092	Primary	Kalamazoo R.
Jamestown	250									
Kalamazoo	86,000			9.7	17796	21275			Act. Sludge	Kalamazoo R.
Allied Paper Co. Bryant Div.				4.8			11200	8100	city sewer clarifier	
Brown Paper Co. KVP # 4 & 7									city sewer save-all	
Brown Paper Co. Sutherland Div.#1									city sewer save-all	
Brunswick Corp.			oil - 12.6 lbs/day pH 7.8	0.25					city sewer sedimentation	Allen Ck.
Consumer Power Co.										Kalamazoo R.
Hawthorne Paper Co.									city sewer save-all	
Kalamazoo Paper Company									city sewer clarifiers	
Lakeside Refining Company			cooling water						floatation skimming recovery	Allen Ck.

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WASTE SOURCES: MICHIGAN

KALAMAZOO RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD5	Raw SS	Discharge BOD5	Discharge SS	Treatment Provided	Receiving Waters
National Gypsum Co.									city sewer save-all	
Rex Paper Co.									city sewer septic tank save-all	
Upjohn Co.				0.6			18	47	city sewer trickling filter, chlorinator injection irrigation	
Marshall	6,736			2.14	1321	1892	1107	768	Primary new oil	Kalamazoo R.
Eaton, Yale & Towne			pH 7.8, oil 3 ppm	0.1				10	treatment in Oct. 1967, waste to pond	Kalamazoo R.
New Richmond										
Olivet	1,185									Indian Ck.

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WASTE SOURCES: MICHIGAN

KALAMAZOO RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Raw SS	Discharge BOD_5	Discharge SS	Treatment Provided	Receiving Waters
Brown Paper Co. KVP #2									city sewer save-all	
Parma	770									
Plainwell	3,125			0.314	587	668	139	194	trickling filter	Kalamazoo R.
Plainwell Canning Co.				0.4			494		city sewer spray irrig. for some waste aerated lagoon & clarifier	
Murray Packing Co.				0.2			995	432	septic tank settling grease trap & sand filter	Drain to Kalamazoo R.
Weyehauser Co.				1.75			3800	2600	city sewer clarifier	
Portage	6,000			0.1	295	274	29	19	Act. Sludge	

APPENDIX D
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WASTE SOURCES: MICHIGAN

KALAMAZOO RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Raw SS	Discharge BOD_5	Discharge SS	Treatment Provided	Receiving Waters
Otsego	4,142			0.46	1563	1213	703	250	trickling filter	Kalamazoo R.
MacSim Bar Paper Co.				1.1			2600	935	city sewer chemical coag. settling & re-use of solids	Kalamazoo R.
Otsego Falls Paper Mill, Inc.				0.4			12000	3400	city sewer use liquor wastes for wood binder	Kalamazoo R.
Parchment	1,565			0.319	396	447	72	72	trickling filter	Kalamazoo R.
North American Extrusion Corp.				0.7				124	septic tank neutrali-zation, stab.pond	Travis Ck.
Brown Paper Co. KVP #1									city sewer filtration vacuum washer and settling lagoons	

APPENDIX D
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WASTE SOURCES: MICHIGAN

KALAMAZOO RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Saugatuck	927			0.4	760	903	650	448	Primary	Kalamazoo R.
Springport	693									
Wayland Pet Milk Co.	2,019			0.05			195	27		Rabbitt R.

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WASTE SOURCES: MICHIGAN

BLACK RIVER BASIN (MIDDLE)

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Raw SS	Discharge BOD_5	Discharge SS	Treatment Provided	Receiving Waters
Beechwood	2,323									
Borculo	125									
Drenth	100									
Forest Grove	120									
Greatschap	100									
Holland	24,777	23,000			5300	-	3600	-	Primary	L. Macatawa
Bohn Aluminum Extrusions				0.2		24		52	City Sewer Nickel Rec. Neutraliz.	Wildwood Dr. to Lake Macatawa
H. J. Heinz Co.				.87			1960	1070	City Sewer	L. Macatawa
Hart & Cooley Mfg. Co.				0.1			32	22	Sep. Tank Stab. Ponds	Black River
Holland Die Castings, Inc.			Cr 0.4 ppm Cu 4 ppm	0.1					Sep. Tank Chem. Trt. of Chrome & CN Settling	Black River
Holland Succo			Cl 5700 lbs/day pH 10.6	0.8			1879	389	Sep. Tank Clarifier	L. Macatawa
James DeYoung Generating Station									None	L. Macatawa

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WASTE SOURCES: MICHIGAN

BLACK RIVER BASIN (MIDDLE)

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD5	Raw SS	Discharge BOD5	Discharge SS	Treatment Provided	Receiving Waters
Holland Parke-Davis Co.							194	-	Primary Plus Chlorination	L. Macatawa
Jamestown	300									
Jenison Park	200									
Macatawa Park	1,500				260	-	200	-	Minor	L. Michigan
Maplewood	800									
New Gronisen	150									
Oaklawn	750									
Ottawa Beach	150									
Overisel	150									
Waukazoo Park	300									

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WASTE SOURCES: MICHIGAN

BLACK RIVER BASIN (MIDDLE)

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD5	Raw SS	Discharge BOD5	Discharge SS	Treatment Provided	Receiving Waters
Zeeland	3,702	3,900			620	810	30	80	Act. Sludge	Black R.
DeWitt's				.1					Sep. Tank Screen & Sand Filters	Black River
Mead-Johnson Co.				.1			91	197	Combined Act. Sludge	Black River
Miles Labs.				0.8			1879	389	City Sewer Pkg. Aeration Sys. Cooling Water to River	Hunters Cr.

APPENDIX D
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WASTE SOURCES: MICHIGAN

GRAND RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Raw SS	Discharge BOD_5	Discharge SS	Treatment Provided	Receiving Waters
Ashley	448									
Bailey	240									
Bath Township										
Belding	4,887	1,900								Flat R.
Gibson Ref. Mfg.				0.04					Oil. Sep.	Flat R.
Byron Center	650									
Caledonia	739	720								Thornapple Cr.
Casnovia	371									
Carson City	1,201									
Carson Cty Crystal Refinery				0.04						Grand R.
Cedar Springs	1,768	1,700								Cedar Creek
Coopersville	1,584	1,500		0.21	394	355	128	126	Trickling Filter	Deer Creek
Samary Food Prod.				0.03			300			Deer Creek
Pet Milk Co.										Deer Creek

APPENDIX D
USDI - FWPCA
WASTE SOURCES: MICHIGAN

GRAND RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD5	Raw SS	Discharge BOD5	Discharge SS	Treatment Provided	Receiving Waters
Cuttlerville	500									
State Hospital	500	500								Buck Creek
Delhi Township	11,339	6,200		0.19	455	480	200	137	Primary	
Delta Township				0.7	1234	1264	126	72	Act. Sludge	
Olds Div. Gen. Motors Corp.				0.07					Chem. Trt. Lagoon	
DeWitt	1,238			0.05	2168	2936	1585	1134	Primary	
Dimondale	866									
East Lansing	30,198	35,000		6.4	6512	8381	1548	4644	Act. Sludge	Cedar River
Eaton Rapids	4,052	4,000		0.27	803	655	527	326	Primary	Grand River
Edmore	1,234									
Fenton	6,142			0.53	707	933	385	477	Primary	
Ferrysburg	2,590									

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WASTE SOURCES: MICHIGAN

GRAND RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD5	Raw SS	Discharge BOD5	Discharge SS	Treatment Provided	Receiving Waters
Fowler	854	700							Trickling Filter	Story Creek
Fowlerville	1,674	550								Red Cedar R.
Fruitport	1,037									
Grand Haven	11,066	11,000		1.91	2453	2039	1131	892	Primary	
ASP Mfg. Co.				0.08					Chem. Precipipation Neut.	Grand R.
Eagle Ottawa Leather Co.			ABS - 25 ppm	1.4			15,000	23,000		Grand R.
Jervis Corp.				0.78					Chem. Tr. of Cyan. & Chrome Sed.	Grand R.
Muni. Power Plant				0.34						Grand R.
Grand Ledge	5,165	5,100		0.48	796	932	444	344	Primary	Grand R.

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WASTE SOURCES: MICHIGAN

GRAND RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD5	Raw SS	Discharge BOD5	Discharge SS	Treatment Provided	Receiving Waters
Grand Rapids	177,313	210,000		37.1	29703	39914	4022	6498		Grand R.
Gen. Motors				2.0						Grand R.
Fisher Body #2										
Packaging Corp. of America				2.52			3180	6700		Grand R.
Grandville	7,975	2,000		0.72	828	1410	78	54	Act. Slud.	Grand River
Greenville	7,440	7,400		1.05	1638	1787	1034	648	Primary	Flat R.
Federal Mogul				0.03					Evaporation Rinses to River	Flat R.
Gibson Ref. Co.				0.1					Settling Lagoon	Flat R.
Hastings	6,375	6,350		0.37	729	825	510	355	Primary	Thornapple R.
Hudsonville	2,649									
Hudsonville				0.017						Rush Cr. to Grand R.

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WASTE SOURCES: MICHIGAN

GRAND RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Raw SS	Discharge BOD_5	Discharge SS	Treatment Provided	Receiving Waters
Ionia	6,754	6,600							Primary	Grand R.
State Reformatory	3,500	3,500								Grand R.
Jackson	50,720	50,700	Nutrients & BOD	9.07	8169	15581	605	1210	Act. Slud.	Grand R.
Clark Eq. Co.									Lagoon	Grand R.
Hilfinger Corp.				0.24					Cooling and Anodize Rinse to R.	Grand R.
LeFere Forge & Mach. Co.				0.14						Grand R.
N.Y.C. R.R.				0.07						Grand R.
Pittsburg Forging Co.				0.086						Grand R.
State Prison	6,500	6,500		0.9	1291	1104	233	353	Trickling Filter	Portage R.
Kent City	617	600								Ball Cr.
Nat'l Fruit Prod.			Seasonal Discharge	0.1					Stabilization Pond, Ground Seepage Irrigation	Rouge R.
Laingsburg	1,057									

APPENDIX D
USDI - FWPCA
WASTE SOURCES: MICHIGAN

GRAND RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Lake Odessa	1,806	1,800		0.424	733	1508	208	223	Trickling Filter	Jordan L.
Lakeview	1,126									
Lansing	107,800	130,000		22.2	29439	63136	1666	4999	Act. Slud.	Grand R.
Leslie	1,807	1,700		0.169	196	206	110	123	Primary	Hunter Cr.
Lowell	2,545	2,530							Primary	Flat R.
Attwood Corp.			CN 1.3 mg/l, Cr 2.8 mg/l, Ni 15.0 mg/l, Zn 1.0 mg/l	0.20				54	Cyanide & Chrome Reduction	Flat R.
Lyons	687									
Mason	4,522	4,520		0.232	510	502			Act. Slud.	Sycamore Cr.
Middleville	1,196	1,180							Primary	Thornapple R.
Electro Chem.				0.436					Chem. Tr. Set. Ponds	Thornapple R.
Keeler Brass Co.									Cyan. Red. Nuetraliz.	Thornapple R.
White Prod. Co.				0.01						

APPENDIX D
USDI - FWPCA
WASTE SOURCES: MICHIGAN

GRAND RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD5	Raw SS	Discharge BOD5	Discharge SS	Treatment Provided	Receiving Waters
Morrice	530									
Muir	610									
Mulliken	484									
Nashville	1,525	1,000		0.17		1334		109	Primary	Thornapple R.
Nunica	250									
Ovid Mich. Milk Prod.	1,505	310		0.5						Alder Cr. Maple R.
Paris Twp. Kroger Company				0.01				51		
Perry	1,370									
Portland	3,330	3,300		0.29	615	795	357	352	Primary	Grand R.
Potterville	1,028									
Ravenna	801									

APPENDIX D
USDI - FWPCA
WASTE SOURCES: MICHIGAN

GRAND RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Raw SS	Discharge BOD_5	Discharge SS	Treatment Provided	Receiving Waters
Rockford	2,074	2,000		0.48	700	923	288	239	Primary	Rogue R.
Wolverine				0.58			2150	750	Primary	
World-wide									Aeration	Rogue R.
St. Johns	5,629	5,600		0.65	780	840	70	163	Filter	Hayworth Cr.
Sand City										
Saranac	1,081									
Sheridan	606									
Carnation Milk Co.				0.36			129	200		
Six Lakes	275									
Mich. Cons. Gas				4.32					Trickling Filter	Flat R.
Sparta	2,749	2,740		0.27	595	785	78	107	Filter	Rogue R.
Spring Lake	2,063	2,060		0.29	395	448	274	202	Primary	Spring Lake
Stanton	1,139									
Sunfield	626									
Trent										

APPENDIX D
USDI - FWPCA
WASTE SOURCES: MICHIGAN

GRAND RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Raw SS	Discharge BOD_5	Discharge SS	Treatment Provided	Receiving Waters
Walker Twp. Bissell Sweeper Co.				0.03			20	10	Nickel & Chrome Recovery	Indian Mill Creek
Webberville	664									
Westphalia	560									
Williamston	2,214	2,220		0.05	81	105	61	38	Primary	Red Cedar R.
Woodland	374	500		0.027					Screen Trickling Filter	L.Thornapple R.
Wyoming	56,000			7.25	6047	9373	1149	1996	Filter	Grand R.
American Motors									Cooling Water to Cr.	Plaster Cr.
GM Diesel Eq.				.120-Process 2.0-Cooling					Cyanide & Chrome Red. Settling	Plaster Cr. Via County Dr.
Light Metals Corp.				0.54				344	Oil Removal Chemical Neut. Sedimentation Sludge Lagoon	Roy's Cr. Drain

APPENDIX D
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WASTE SOURCES: MICHIGAN

MUSKEGON RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Raw SS	Discharge BOD_5	Discharge SS	Treatment Provided	Receiving Waters
Aetna										
Altona	150									
Amble										
Ashland Center										
Ashton	115									
Avondale										
Big Prairie										
Big Rapids	8,686			0.6	1090	1145	490	460	Primary	Muskegon R.
Central Concrete Products									Sep. Tank	Muskegon R.
									Settling Ponds	
Denham Mfg. Co.										Muskegon R.
Mid-America Engineering Corp.				0.06					Sep. Tank Settling	Ryan Cr.
Paris Sand & Gravel Co.									Settling Ponds	Muskegon R.
Bishop										

APPENDIX D
USDI - FWPCA
WASTE SOURCES: MICHIGAN

MUSKEGON RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD5	Raw SS	Discharge BOD5	Discharge SS	Treatment Provided	Receiving Waters
Bridgeton										
Borland										
Butterfield										
Cadillac	10,112			0.95	1647	1837	238	411	Act. Sludge	Clam River
Brook & Perkins										Clam River
Chippewa Lake										
Croton	250									
Cutcheon										
Evart	1,775			0.28	164	166	68	112	Primary	Muskegon R.
Liberty Dairy			Whey	0.17						Muskegon R.
Falmouth	250									
Fremont	3,384	3,350		0.3	1447	632	42	76	Trickling Filter	Brooks Cr.
Gerber Prod.				1.0					Scr. Fil. City and Spray Cooling Water to Stream	Darling Cr.

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USDI - FWPCA
WASTE SOURCES: MICHIGAN

MUSKEGON RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Raw SS	Discharge BOD_5	Discharge SS	Treatment Provided	Receiving Waters
Fremont Speas Co.				1.12					City Sewer	Cole Drain
Grant	732	700		0.04	104	132	7	15	Screen Filter	
Grant Center										
Hersey Wallace Stone Co.	246		Sediment						Process Settling	Muskegon R.
Howard City	1,004									
Houghton LakesHgts	1,195									
Lake City	718									
Lake Harbor	350									
Lucas	100									
McBain	551									
Maple Hill										

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USDI - FWPCA
WASTE SOURCES: MICHIGAN

MUSKEGON RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD5	Raw SS	Discharge BOD5	Discharge SS	Treatment Provided	Receiving Waters
Marion	898									
Markey										
Mecosta	303									
Merritt										
Moddersville										
Moorestown										
Moorland										
Morley	445									
Muskegon	46,485	46,000		7.86	8324	9177	6096	3343	Primary	Muskegon L.
Campsbell Waynt & Cannon									City & Oil Recovery	Ruddiman Drain
Consumer Power Co.			Heat							Muskegon R.
Continental Motors Corp.									City & Oil Separator	Muskegon L.

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USDI - FWPCA
WASTE SOURCES: MICHIGAN

MUSKEGON RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD5	Raw SS	Discharge BOD5	Discharge SS	Treatment Provided	Receiving Waters
Muskegon Continental Motors Corp.									CN & Chrome Destruction Oil Separation, Acid Neutralizing City Sewer	Muskegon R.
Kaydon Engr.									Clarifiers	S. Branch Ruddiman Cr.
Lakeway Chem. Inc.				0.5					Sep. Tank Lagoons & Seepage Lagoons	L. Black R. to Mona L. Groundwater & Little Berr Creek
Ott Chem. Co.			New disposal system under construction - will utilize Muskegon River for effluent disposal.							
S. D. Warren Co.			BOD - Sediment				13500	18000	Clarifiers City, Save-all	Muskegon L
Muskegon Heights Sealed Power Corp.	19,552	19,500		1.86	3676	4358	356	326	Act. Sludge City Sewer & Destruction of Chrome	L. Black R. Ruddiman Dr.

APPENDIX D
USDI - FWPCA
WASTE SOURCES: MICHIGAN

MUSKEGON RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Raw SS	Discharge BOD_5	Discharge SS	Treatment Provided	Receiving Waters
Nellsville										
Newaygo	1,447			0.08	107	133	70	42	Primary	
North Muskegon Naph-Sol	3,855	3,850	Oil 112 lbs/day Phenols 7.8 lbs/day Cl^- 1248 lbs/day	Cooling 5.8 Process 0.07			229	405	Primary Sep. Tank API Separator Lagoons	No. Channel Cedar R.
Oak Grove										
Park Lake										
Paris	180									
Pierson	219									
Pogy										
Prosper										
Prudenville	100									

APPENDIX D
USDI - FWPCA
WASTE SOURCES: MICHIGAN

MUSKEGON RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Raw SS	Discharge BOD_5	Discharge SS	Treatment Provided	Receiving Waters
Reed City	2,184			0.4	2131	923	930	595	Primary	
Rodney										
Rustford										
Sears										
Star City										
Stittsville										
Sullivan										
Temple	100									
Sylvester										
Wolf Lake	2,525									

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WASTE SOURCES: MICHIGAN

WHITE RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Ferry	200									
Hesperia	822									
Huber										
Jugville										
Montague	2,366									
E. I. Du pont Co.			Cu 72 lbs/day NH_3 2395 lbs/day Cl^2 9955 lbs/day CN 46 lbs/day Ca 5338 lbs/day	17.3			4328	-	Sep. Tank Coagulation & Sedimentation	L. Michigan
Hooker Chem. Co.			Cl^- 62,000 lbs/day	9.0			-	3,000	Sedimentation, Sand Filtration Settling	White Lake
New Era New Era Can. Co.	403								Sep. Tank Lagoon	Groundwater

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WASTE SOURCES: MICHIGAN

WHITE RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Raw SS	Discharge BOD_5	Discharge SS	Treatment Provided	Receiving Waters
Ramona										
Rathburg	200									
White Cloud	1,001			0.46	1037	730	372	146	Primary	White R.
Whitehall	2,590	2,500		0.2	284	280	193	102	Primary	White Lake
Whitehall Leather Co.			Sus.Vol. Solids 500 lbs/day pH 10.8	1.2			2100	608	City Sewer Lagoon to White L.	White Lake
Misco Precision									City Sewer Floor Traps to Lake	White Lake
Woodville										

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USDI - FWPCA
WASTE SOURCES: MICHIGAN

PENTWATER RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Bass Lake	100									
Crystal Valley	100									
Hart	1,990	1,000							Lagoon City Sewer	Hart Lake
Hart Cherry Packers									Screen Spray Irri.	
Stokely Van Camp, Inc.			pH 5.4						City Sewer Screen Spray Irri.	
Mears	250									
Oceana Beach										
Pentwater	1,030									
Shelby	1,603									
Stony Lake	100									

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USDI - FWPCA
WASTE SOURCES: MICHIGAN

PERE MARQUETTE RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD5	Raw SS	Discharge BOD5	Discharge SS	Treatment Provided	Receiving Waters
Baldwin	835									
Bitely	340									
Branch										
Brohman										
Idlewild	70									
Lilley										
Ludington	9,421	9,420		1.76	1130	1365	572	925	Primary	P. Marquette L. L. Michigan
Consumers Power Co.			Heat							
Dow Chemical Co.			Sus. Solids						City Sewer Clarifier Brine to L. Mich.	L. Michigan & P. Marquette R.
Harbison-Walker Refractories Co.			Sus. Solids	5.35				700	Sep. Tank Clarifiers Coagulant Acids	P. Marquette R.
Nirvana										

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USDI - FWPCA
WASTE SOURCES: MICHIGAN

PERE MARQUETTE RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD5	Raw SS	Discharge BOD5	Discharge SS	Treatment Provided	Receiving Waters
Scottsville	1,245	1,245							None	P. Marquette R.
Stokely Van Camp, Inc.				0.5	-	-	382	492	Sep. Tank Screen	P. Marquette R.
Tallman Center										
Volney										
Walhalla	250									
Walkerville	261									
Wiley										
Woodland Park	410									

APPENDIX D
USDI - FWPCA
WASTE SOURCES: MICHIGAN

BIG SABLE RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Freesoil	209									
Hamlin Lake										

APPENDIX D
USDI - FWPCA
WASTE SOURCES: MICHIGAN

MANISTEE RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD5	Raw SS	Discharge BOD5	Discharge SS	Treatment Provided	Receiving Waters
Eastlake	436									
Michigan Chem. Corp.				0.16					Sep. Tank	Manistee L. L. Michigan
Filer City	934									
Great Lakes			Cl^- 601,000 lbs/day	0.4					Sep. Tank Brine Wells	Manistee L. L. Michigan
Packaging Corp. of America				12.4	-	-	33,000	10,000	Sep. Tank Save-all	Manistee L. L. Michigan
Grayling	2,015									
Hoxeyville	-									
Kaleva	348									
Leroy	267									
Manistee	8,324			0.52	790	673	556	299	Primary	Manistee R.
Manistee Salt Co.			Cl^- 44,700 lbs/day	6.7					City Sewer $CaSO_4$ to Deep Well	Manistee L. Manistee Channel

APPENDIX D
USDI - FWPCA
WASTE SOURCES: MICHIGAN

MANISTEE RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Manistee (Cont'd)										
Morton Salt Co.			Cl^- 26,000 lbs/day	0.1					City Sewers Eductors	Manistee L. Manistee Ch.
Standard Lime & Cement Co.			Cl^- 520,000 lbs/day	0.6					Sep. Tank Eductors	Manistee L. L. Michigan
Sherman	-									
Tustin	248									

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USDI - FWPCA
WASTE SOURCES: MICHIGAN

BETSIE RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD5	Raw SS	Discharge BOD5	Discharge SS	Treatment Provided	Receiving Waters
Benzonia	407									
Smeltzer Pkg. Co.									Sep. Tank Lagoon Scr.	Herring L. Fierring L.
Elberta	552	550		0.081	109	144	68	58	Primary	Betsie R.
Elberta Can. Co.									City Sewer Screen	
Frankfort	1,690	1,690		0.14	465	257	391	125	Primary	Lake Aux Betsies
Crystal Can. Co.				0.42			760	150	Screen	Betsie L.
Onekema	469									
Onekema Can. Co.									Sep. Tank Screen	Portage L.

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USDI - FWPCA
WASTE SOURCES: MICHIGAN

LEELANAU PENINSULA AREA

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Leelanau										
Elk Rapids Packing				0.14					screen & chlorination	Lake Leelanau
Northport	530									
Northport Cherry Factory									screen	Grand Traverse Bay
Suttons Bay										
Frigid Foods, Inc.									city sewer screen	Grand Traverse Bay

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USDI - FWPCA
WASTE SOURCES: MICHIGAN

BOARDMAN RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD5	Raw SS	Discharge BOD5	Discharge SS	Treatment Provided	Receiving Waters
Darragh										
Fife Lake	218									
Grawn Cherry Growers, Inc.									spray irrigation screen	Ground Water
Kalkaska	1,321									
Kingsley	586									
Mayfield										
South Boardman										
Traverse City Bay St. Steam Plant	18,432	21,305	Heat	3.60	6094	5554	4923	1981	Primary	Boardman R. Grand Traverse Bay

APPENDIX D
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WASTE SOURCES: MICHIGAN

BOARDMAN RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Traverse City Canning Co.									city sewer screening	Boardman River

APPENDIX D
USDI - FWPCA
WASTE SOURCES: MICHIGAN

AREA FROM CHARLEVOIX TO TRAVERSE CITY

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Acme										
Bates										
Northwood										

APPENDIX D
USDI - FWPCA
WASTE SOURCES: MICHIGAN

ELK LAKE BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Alden	350									
Antrim	300									
Barker Creek										
Bellaire										
Central Lake	602									
Clam River										
Eastport										
Elk Rapids	1,015	975		0.2	101		65		Primary	Elk R.
Ellsworth	386									
Kewadin										
Leetsville										
Rapid City	250									

APPENDIX D
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WASTE SOURCES: MICHIGAN
ELK LAKE BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Torch Lake										
Williamsburg										

APPENDIX D
USDI - FWPCA
WASTE SOURCES: MICHIGAN

LAKE CHARLEVOIX BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD5	Raw SS	Discharge BOD5	Discharge SS	Treatment Provided	Receiving Waters
Advance Northern Michigan Electric Power Coop.			Heat							Lake Charlevoix
Alba	450									
Boyne City	2,797			0.2	161	174	90	71	Primary city sewer	Pine R.
Howes Leather Co., Inc.				0.4			1790	2200	lagoon clarifier	Lake Charlevoix
Boyne Falls	260									
Charlevoix	2,751			0.38	685	638	410	202	Primary	Pine R.
Medusa Portland Cement										L. Michigan
East Jordan	1,919			0.08	80	109	46	46	Primary city sewer	L. Charlevoix
East Jordan Canning Co.									lagoons	Jordan R.
Elmira	150									

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WASTE SOURCES: MICHIGAN

LAKE CHARLEVOIX BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Horton Bay										
Ironton										
Mancelona	1,141									
Mt. Clemens Metal Prod.									septic tank lagoons	

APPENDIX D
USDI - FWPCA
WASTE SOURCES: MICHIGAN

AREA FROM THE STRAITS OF MACKINAC TO CHARLEVOIX

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Bay View		2,000							Primary	L. Michigan
Bay Shore	160									
Big Rock Point Consumers Power			Heat							L. Michigan
Bliss										
Carp Lake										
Clarion										
Cross Village	300									
Good Hart										
Harbor Springs	1,433	1,430			243		194		Primary	Little Traverse Bay
Levering	320									

APPENDIX D
USDI - FWPCA
WASTE SOURCES: MICHIGAN

AREA FROM THE STRAITS OF MACKINAC TO CHARLEVOIX

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Raw SS	Discharge BOD_5	Discharge SS	Treatment Provided	Receiving Waters
Petoskey	6,138	6,100		0.8	1694	2172	1223	541	Primary	Little Traverse Bay
Penn-Dixie Cement Corp.									septic tank settling pond	Little Traverse Bay
Petoskey Plating Company				0.097					city sewer part chemical treatment	Bear R.
Ramona Park										
Stutsmanville										
Walloon Lake	170									
Wequetonsing	1,000	1,000			170		119		Primary	Little Traverse Bay

APPENDIX D
USDI - FWPCA
WASTE SOURCES: MICHIGAN

AREA FROM MANISTIQUE TO THE STRAITS OF MACKINAC

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Allenville										
Brevort	93									
Engadine	475									
Epoufette										
Garnet										
Gilchrist										
Gould City	300									
Gros Cap	50									
Gulliver Inland Lime & Cement Co.				0.16					septic tank settling ponds	L. Michigan
Millecoquins										

APPENDIX D
USDI - FWPCA
WASTE SOURCES: MICHIGAN

AREA FROM MANISTIQUE TO THE STRAITS OF MACKINAC

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Moran	260									
Naubinway	183									
Rexton										

APPENDIX D
USDI - FWPCA
WASTE SOURCES: MICHIGAN

MANISTIQUE RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Big Carning										
Blany Park										
Curtis										
Cusino										
Germfask	250									
Helmer										
Hiawatha	300									
Manistique										
Manistique Pulp & Paper Co.			Sus. Volatile solids 10,439 lbs/day	2.0			2729	16572	city sewer save-all, ponds	L. Michigan
Mestrand										
Seney	250									

APPENDIX D
USDI - FWPCA
WASTE SOURCES: MICHIGAN

MANISTIQUE RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Shingleto..	400									
Steuben										

APPENDIX D
USDI - FWPCA
WASTE SOURCES: MICHIGAN

FISHDAM RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Cooks	300									
Fairport	250									
Fayette										
Garden	380									
Isabella	227									
Thompson	244									

APPENDIX D
USDI - FWPCA
WASTE SOURCES: MICHIGAN

STURGEON RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Nahma	700									
Nahma Junction										

APPENDIX D
USDI - FWPCA
WASTE SOURCES: MICHIGAN

STONINGTON PENINSULA

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Ensign	402									
Stonington	410									

APPENDIX D
USDI - FWPCA
WASTE SOURCES: MICHIGAN

WHITE FISH RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste / Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Keleva										
Lawson										
Traunik										
Trenary	300									

APPENDIX D
USDI - FWPCA
WASTE SOURCES: MICHIGAN

RAPID RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Lathrup										
McFarland										
Rapid River										
Rapid River Div. of Mich.Milk Prod. Assn.			Whey						septic tank haul whey	Rapid R.

APPENDIX D
USDI - FWPCA
WASTE SOURCES: MICHIGAN

DAYS RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD5	Raw SS	Discharge BOD5	Discharge SS	Treatment Provided	Receiving Waters
Brampton	300									
Gladstone	5,267	5,260	BOD & SS	0.672	1294	1456	885	616	Primary	Little Bay de Noc
Masonville										
Perkins										
Rock	475									
Trombly										

APPENDIX D
USDI - FWPCA
WASTE SOURCES: MICHIGAN

ESCANABA RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Raw SS	Discharge BOD_5	Discharge SS	Treatment Provided	Receiving Waters
Arnold										
Austin										
Cornell										
Escanaba	15,391	15,390		1.35	2410	2139	315	378	Act. sludge trickling filter	Portage Ck.
Mead Corp. Escanaba Div.				4.3			8850	30000	septic tank Svan-Pederson save-all	Escanaba R.
Gwinn	1,009									
Helena										
Humboldt										
Little Lake										
National Mine	500									

APPENDIX D
USDI - FWPCA
WASTE SOURCES: MICHIGAN

ESCANABA RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
New Swanzy										
Palmer	850			0.08					septic tank	
Princeton	450									
Watson										
Wells	500									

APPENDIX D
USDI - FWPCA
WASTE SOURCES: MICHIGAN

FORD RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Channing	600									
Ford River	100									
Henderson	250									
Hyde										
La Branche										
Mashek										
Northland										
Perronville	100									
Pine Ridge										
Reade										
Sagola	100			0.01					septic tank	
Turner	206									
Whitney										

APPENDIX D
USDI - FWPCA
WASTE SOURCES: MICHIGAN

BARK RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Bark River	800									
Schaffer	250									

APPENDIX D
USDI - FWPCA
WASTE SOURCES: MICHIGAN

BIG CEDAR BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Cedar River	180									
Gourley										
Harris										
Powers	383									
Spalding	300									
Wilson	750									

APPENDIX D
USDI - FWPCA
WASTE SOURCES: MICHIGAN

ARTHUR BAY

Community or Industry	Population (1960)	Population Served	Type of Waste / Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Arthur Bay										
Edgewood Beach										
Ingallston	150									
Johnson Landing										
Long Beach										
Utopia Beach										

APPENDIX D
USDI - FWPCA
WASTE SOURCES: MICHIGAN

MENOMINEE RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Alpha	317	300							septic tank	Mastodon Ck.
Amasa	800									
Bagley										
Banat										
Basswood										
Beace										
Beechwood	2,223									
Birch Creek										
Bird										
Blom										
Carbondale										

APPENDIX D
USDI - FWPCA
WASTE SOURCES: MICHIGAN

MENOMINEE RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Carney										
Caspian	1,493	1,490		0.15					Imhoff tank	Iron R.
Champion	750									
Crystal Falls	2,203									
Cunard										
Daggett	296									Little Cedar R.
Cloverleaf Coop. Cheese Co., Div. Michigan Milk Prod. Assn.									septic tank	
Daggett Cheese Company									whey hauled	Little Cedar R.
									septic tank	Little Cedar R.

APPENDIX D
USDI - FWPCA
WASTE SOURCES: MICHIGAN

MENOMINEE RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Elmwood										
Faithorn										
Felch	200									
Felch Mountain										
Foster City	200									
Gaastra	582	580		0.06					septic tank	Iron R.
Gardner										
Gibbs City										
Granite Bluff										
Hardwood										
Hermansville	750									

APPENDIX D
USDI - FWPCA
WASTE SOURCES: MICHIGAN

MENOMINEE RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD5	Raw SS	Discharge BOD5	Discharge SS	Treatment Provided	Receiving Waters
Hills										
Ingalls										
Iron Mountain	9,299	9,290	(See Kingsford)							Menominee R.
Iron River	3,754	3,750		.302	342	406	244	192	Primary septic	Iron R.
Hanna Mining Company			pH 5.3					40	tank lagoon for mine drainage	Iron R.
Inland Steel Co.				0.360				252	septic tank lagoon for acid mine drainage	Iron R.
Kells										
Kingsford	5,084	5,080		1.18	2755	3238	1889	875	Primary	Menominee R.

APPENDIX D
USDI - FWPCA
WASTE SOURCES: MICHIGAN

MENOMINEE RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Raw SS	Discharge BOD_5	Discharge SS	Treatment Provided	Receiving Waters
Longrie										
Loretto	250									
Menominee	11,289	11,280		1.89	1403	1686	961	788	Primary city sewer	Menominee R.
American Can Co. Menominee Mill			Sus. volatile solids 4,000 lbs/day	1.226*			1668	5489	Pederson & vacuum disc. save-alls	Menominee R.
	*Presently constructing clarifier and sludge thickening facility for entire mill waste.									
Scott Paper Co. Ground Wood Mill			Suspended solids	.075					save-alls	Menominee R.
Merriman										
Michigamme	400									
Nadeau										

APPENDIX D
USDI - FWPCA
WASTE SOURCES: MICHIGAN

MENOMINEE RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Raw SS	Discharge BOD_5	Discharge SS	Treatment Provided	Receiving Waters
Nathan										
Nestoria										
Norway	3,171	3,170								Sewer Ck.
Quinnesec										
Randville										
Republic	400			0.04					septic tank	
Stager										
Stambaugh	1,876	1,870		0.09	141	195	31	29	Act. sludge	Iron R.
Stephenson	820	820		.179	349	273	55	52	Trickling Filter	

APPENDIX D
USDI - FWPCA
WASTE SOURCES: MICHIGAN

MENOMINEE RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
Palestine Cheese Co.				0.02					septic tank haul whey	Little Cedar R.
White House Milk Co.				.39			46	42	septic tank combined waste sec. tr. trickling filter	Little Cedar R.
Swanson										
Talbot										
Theodore										
Three Lakes										
Triangle Ranch										
Vulcan	450			0.04					septic tank	
Wallace										
Waucedah										
Witch Lake										

APPENDIX E
USDI - FWPCA
WASTE SOURCES: WISCONSIN

MENOMINEE RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD5	Raw SS	Discharge BOD5	Discharge SS	Treatment Provided	Receiving Waters
FLORENCE (unin.)	1,000	750	Sewage & Ind. W.	.1			100		Lagoon	Weber Cr. to Bride R. to Menominee R.
GOODMAN (unin.)	780	600	Sewage	.021			13		Secondary	S. Branch Chemical Cr.
MARINETTE, City	13,329	13,000	Sewage & Ind. W.	3.0			1,670		Primary	Menominee R.
Ansul Chem. Co.			Industrial Waste						None	Menominee R.
Scott Paper Co.			Pulp & Paper	6.5			36,120			Menominee R.
NIAGARA, Village	2,098	2,000	Sewage	.528			250			Menominee R.
Kimberly Clark Co.			Ground Wood & Paper Mill	10.2			*			Menominee R.
Wausaukee Cheese Fac.			Floor Drains-Whey is hauled to disposal sites							Wausaukee R. to Menominee River

* Sulfite Mill operation discontinued

APPENDIX E
USDI - FWPCA
WASTE SOURCES: WISCONSIN
PESHTIGO RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
BEAVER										
Riverside Cheese Fac.			Milk & Cheese Wastes						Irrig. & Hauling	Main Stem Peshtigo R.
COLEMAN, Village	718	700	Sew. & Cheese Wastes	.118			42		Secondary	Little Peshtigo R.
Country Gardens			Canning Wastes						Spray Irrig.	Little Peshtigo R.
CRANDON, City of	1,679	550	Sewage	.037			46		Secondary	So. Branch Peshtigo R.
LAONA (unincor.)			Sewage						None	Rat River
PESHTIGO, City of	2,504	2,800		.525			155		Secondary	Peshtigo R.
Badger Paper Mills, Inc.			Pulp & Paper Wastes	4.73			18,930		Savealls	Peshtigo R.

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WASTE SOURCES: WISCONSIN

OCONTO RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
GILLETT	1,374	1,370	Mun. & Ind. Wastes	.105			46		Act. Sludge	Cristie Br.
Country Gardens			Canning Wastes						Spray Irrig.	Cristie Br.
Townline Fac.			Cheese Factory						Sep. Tank & Dry Well	Trib. to Daly Creek
LENA, Village of	560	500	Mun. & Cheese Fac.	.25			715		Sec.	Jones Cr.
OCONTO, City of	4,805	4,700	Mun. & Industrial	.938			225		Sec.	Main Stem Oconto R.
OCONTO FALLS, City	2,331	2,300	Mun. & Ind. Wastes	.2			100		Sec.	Main Stem Oconto R.
Scott Paper Co.			Pulp & Paper	10.6			47,860		Lag.&Haul.	Main Stem Oconto R.
WABEND (unincor.)			Sanitary						None & Sep.T.	N. Br. of Oconto R.

APPENDIX E
USDI - FWPCA
WASTE SOURCES: WISCONSIN

DUCK AND PENSAUKEE RIVER DRAINAGE BASINS

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Raw SS	Discharge BOD_5	Discharge SS	Treatment Provided	Receiving Waters
DE PERE										
Chicago Corners Cheese Fact.			Milk & Cheese Wastes	.0035			45		Secondary	Duck Creek
GREEN BAY			Sanitary Sewage						Inadequate	Duck Creek
Oneida Golf & Riding Club										
KRAKOW (Unin.)			Sewage						None	Pensaukee R.
Krakow Cheese Factory			Cheese Factory Wastes	.0045			40		Sep.Tk.	Pensaukee R.
OCONTO, RFD #2										
E.C.Swaer & Son Fish Proc.Plant			Sewage & Industrial						None	Pensaukee R.
Swaer Fish Reduction Plant #2			Industrial						None	Pensaukee R.
ONEIDA										
Sacred Heart Seminary				.025			43		Secondary	Duck Creek
PULASKI, Vil. of	1540	1500	Industrial Wastes	.3			80		Secondary	Little Suamico R.

APPENDIX E
USDI - FWPCA
WASTE SOURCES: WISCONSIN
DUCK AND PENSAUKEE RIVER DRAINAGE BASINS

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
PULASKI (Cont.)										
Our Best Canning Co.			Industrial wastes discharged to storm sewer	.05			1000		Screening	Little Suamico R.
Pickle Rite			Connected to Municipal plant but factory is being relocated						Municipal connection	Little Suamico R.
SUAMICO (Unin.)			Sewage						None	Suamico R.
Larry Moore Ranch, Inc.			Sewage & I.W.						None	Suamico R.
Suamico Fish Co.			Untreated Wastes						Sep.Tk.	Suamico R.
Valentine Fisheries, Inc.			Sewage, cooling & processing wastes	.015			50			Suamico R.
ZACHOW (Unin)			Sewage						None	Pensaukee R.
Graf Creamery Co. Inc.			Milk Wastes						Irrigation	Pensaukee R.

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WASTE SOURCES: WISCONSIN
LOWER FOX RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Raw SS	Discharge BOD_5	Discharge SS	Treatment Provided	Receiving Waters
ALLOUEZ TOWN		1440	See De Pere							Fox River
ALLOUEZ TOWN	9,557	7,500	See Green Bay Metropolitan Dist.							Fox River
APPLETON	46,758	47,000	Sewage	9,400			11,667			Fox River
Consolidated Papers, Inc.			Pulp & paper	8.1			30,800	15,240		Fox River
Formost Foods			Industrial Waste	1.28			200			Fox River
Fox River Paper Company			Paper						Discharge to Municipal System	Fox River
Riverside Paper Company			Paper	2.5			1,500	4,000E		Fox River
South Greenville Dairy			Dairy Waste	.0051			51		Hauling	Rat River
Utility District Butte des Morts				.255			19		Secondary	Mud Creek
ASHWAUBENON TOWN	200	200	See DePere							Fox River
COMBINED LOCKS	1,421	1,450	See Kaukauna							Fox River

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WASTE SOURCES: WISCONSIN

LOWER FOX RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD5	Raw SS	Discharge BOD5	Discharge SS	Treatment Provided	Receiving Waters
DE PERE	10,045	10,100	Sewage	1.2			1,063		Secondary	Fox River
Hickory Grove San.			Sewage						Secondary	Fox River
Nickolet Paper			Paper Mill	1.5-1.6			200-500	660-1900		Fox River
U.S.Paper Mills			Paper	0.2-0.6				350-8000		Fox River
GREEN BAY	62,888	62,680	Sewage						See Green Bay Met. Sew.Dist.	Fox River
American Can Co.			Pulp & Paper	16.0			43,000	15,120		Fox River
Charmin Paper Products			Pulp & Paper	14.53			45,920		Waste Evaporators	Fox River
Fort Howard Paper			Paper	11.4			30-32,000	27,880	Save-alls & Lagoons	Fox River
Green Bay Packing			Pulp & Paper				20,000	5,340		Fox River
GREEN BAY METROPOLITAN SAN.DIST.		88,280	Municipal & I.W.	13.5			16,200		Secondary	Fox River
FOX RIVER HEIGHTS	2,000	2,000	Sewage & I.W.						See Green Bay Met. Sew. Dist.	Fox River
FOX RIVER OUTLET #1			Sewage & I.W.						" "	Fox River

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USDI - FWPCA
WASTE SOURCES: WISCONSIN
LOWER FOX RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Raw SS	Discharge BOD_5	Discharge SS	Treatment Provided	Receiving Waters
FOX RIVER OUTLET #2			Sewage and I.W.						See DePere	Fox River
HOLLANDTOWN S.D.			Sewage and I.W.	.061			265		Secondary	Plum Creek
HOWARD	3,485	3,000	Sewage and I.W.						See Green Bay MSD	Fox River
KAUKAUNA	10,096	10,100		1.275			255		Secondary	Fox River
Combined Paper Mills, Inc.			From Chemi-mechanical Pulp and Groundwood	2.4			5,260			Fox River
Thilman Paper & Pulp			Pulp & Paper	26.1			33,000	19,380		Fox River
White Clover Dairy			Milk Wastes							Fox River
KIMBERLY	5,322	5,400	Municipal	0.359E			90		Secondary	Fox River
Kimberly Clark			Pulp & Paper	14.9			48,700			Fox River
LITTLE CHUTE	5,099	5,100	Municipal	0.403E			167		Secondary	Fox River
MENASHA	14,647	14,645	Municipal						See Neenah	Fox River
Gilbert Paper Co.			Paper	0.89			740	640		Fox River
Holiday Inn			Domestic	0.0098			1.3			Fox River
Kimberly Clark Marketing Center										Fox River

APPENDIX E
USDI - FWPCA
WASTE SOURCES: WISCONSIN
LOWER FOX RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD5	Raw SS	Discharge BOD5	Discharge SS	Treatment Provided	Receiving Waters
MENASHA (Cont.)										
Kimberly Clark			Pulp & Paper	.007			1.2		Secondary	Fox River
Menasha Corp.			Pulp & Paper						Secondary	Fox River
Menasha Town San. Dist. #4			Sanitary	0.465			.140			Fox River
John Strange Paper Co.			Paper	1.6			1,840	3,100		Fox River
Geo. A. Whiting Paper Co.			Paper	0.3			380	1,492		Fox River
NEENAH	18,057	32,705	Sewage & I.W.	16.0			2,080		Secondary	Fox River
Bergstrom Paper			Pulp & Paper	4.2			19,700	42,800		Fox River
Galloway Co.			Industrial							Fox River
Kimberly Clark (Badger-Globe)			Pulp & Paper	0.53			140	500		Fox River
Kimberly Clark Neenah Div.			Pulp & Paper	0.53			300	900		Fox River
Lakeview Paper Co.			Paper	5.25			1,460	6,700		Fox River
Neenah Foundry			Industrial Waste							Neenah Slough
Neenah Foundry			Industrial Waste							Neenah Slough
PREBLE TOWN	12,245	12,500	Municipal						See Green Bay MSD	Fox River

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WASTE SOURCES: WISCONSIN
LOWER FOX RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
WRIGHTSTOWN			Municipal	.09			.40		Secondary	Fox River
Wrightstown San. Dist. #1			Municipal	.0165			20		Secondary	East River
Miscellaneous Fox River Sources										
Austin-Straubel S.T.P.			J.W. & Sanitary	.0485			6		Secondary	Dutchman Cr.
Brookside Cheese Factory			Milk Wastes	.005			21			Kankot Cr.
Coehn			Meat Packing							Trib. of Fox River
Fox River Valley Corp.			Paper Mill Wastes	.00285			1		Sand Filter	Ashwaubenon Creek
Fox River Tractor Company			Industrial Waste						Secondary	Mud Creek
Hietpas Dairy Farms			Milk	.0012			2			Trib. of Fox River
Liebmann Packing Co.			Paunch Manure						Lagoon	Bairds Cr.
Pleasant View Cheese Factory			Milk	.004			9			Plum Creek
Shirley Farm Corp.			Cheese, Milk							Boulder Cr.
Wisconsin Rendering Company			Industrial Wastes							Mud Creek

APPENDIX E
USDI - FWPCA
WASTE SOURCES: WISCONSIN
UPPER FOX RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
BERLIN	4836	4830	Municipal	0.905			680		Tr.Filt. (1952) Chlor.	Fox River
Alto Coop. Creamery			Milk	0.032			52.5		Sep.Tk.	Fox River
BYRON			Municipal							
Park Cheese Co.			Milk						Irrigation	E.Br.Fond du Lac R.
CHILTON	2578		Municipal							L.Winnebago
Quincy Cheese Fact.(Swift & Co.)			Milk						Irrigation	L.Winnebago
EDEN	312	310	Municipal	0.028			11		Tr.Filt. (1959)	DeNeveu Cr.
Eden Market									Sep.Tk.	DeNeveu Cr.
Mammoth Springs Canning Co.			Canning						Lagoon	DeNeveu Cr.
White House Milk Co.			Milk						Sludge Tks.	DeNeveu Cr.
Luxerin Farms			Milk	0.012			10		Sep.Tk.	DeNeveu Cr.
ENDEAVOR	280		Municipal							Fox River
Dairy Land Poultry			Poultry	0.1					Ridge & Furrow	Buffalo Lake

APPENDIX E
USDI - FWPCA
WASTE SOURCES: WISCONSIN
UPPER FOX RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Raw SS	Discharge BOD_5	Discharge SS	Treatment Provided	Receiving Waters
FAIRWATER	330		Municipal						Sep. Tk.	Grand River
Amer. Stories Dairy			Canning						Irrigation	Grand River
Cloverdale Dairy			Milk						Irrigation	Grand River
FOND DU LAC	32,719	33,000	Municipal	0.27					Tr. Filt. Chlor.	Winnebago
Luxerin Farms			Milk						Sep. Tk.	DeNeveu Cr.
Manske Mink Farm			Barnyard	0.004					Sep. Tk.	DeNeveu Cr.
South Hill Counry Club			Domestic	0.03					Sep. Tk.	DeNeveu Cr.
FOND DU LAC TWP.			Municipal						Sep. Tk.	DeNeveu Cr.
GREEN LAKE	953	960	Municipal	0.19			34		Act.Sludge (1949)	Puckyan R.
American Baptists Assembly			Domestic	0.03			7		Tr.Filt. (1955) Chlor.	Green Lake
LAMARTINE	1225		Municipal						Sep.Tk.	E.Br. Fond du Lac R.

APPENDIX E
USDI - FWPCA
WASTE SOURCES: WISCONSIN
UPPER FOX RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
MARKESAN	1066	1070	Municipal	0.243			322		Tr. Filt. (1953)	Grand R.
California Packing Co.			Canning						Irrigation	Grand R.
Fall River Canning Co.			Canning						Irrigation	Grand R.
MONTELLO	1021	1000	Municipal	0.176			37		Tr. Filt. (1950)	Montello R.
Montello Swiss Cheese Fact.			Milk						Irrigation	Montello R.
Spring Cheese Fact.			Milk						Irrigation	Montello R.
Town Hall Dairy Coop.			Milk						Irrigation	Montello R.
Wittenwyle Bury Cheese Fact.			Milk						Irrigation	Montello R.
NORTH FOND DU LAC	2549	2550	Municipal	0.40					Tr. Filt. Chlor.	L.Winnebago
OAKFIELD	772	770	Municipal						Act.Sludge (1956)	Camp Ground Creek
Mammoth Spring Canning Co.			Canning	0.006					Irrigation Lagoon	Camp Ground Creek

APPENDIX E
USDI - FWPCA
WASTE SOURCES: WISCONSIN
UPPER FOX RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD5	Raw SS	Discharge BOD5	Discharge SS	Treatment Provided	Receiving Waters
OMRO	1991	1990	Municipal	0.177			200		Primary (1947) Chlor.	Fox River
Kraft Foods, Inc.			Milk						Sludge Tks. Irrigation	Fox River
OSHKOSH	45,110	50,685	Municipal Combined Sewers	6.5			5840		Primary, Chlor.	Fox River
Cowan Farms			Milk	0.26					None	L.Winnebago
Hopp's Mobile Homes			Domestic						Act.Sludge Lagoon	L.Butte des Morts
Pure Oil Co.			Industrial						Act.Sludge Lagoon	L. Butte des Morts
Skeleton Bridge Cheese Fact.			Milk	0.009			2		Sep.Tk.	Daggets Cr.
PARDEEVILLE	1331	1300	Municipal	0.075			43		Tr.Filt. (1950)	Fox River
Pardeeville Canning Co.			Canning						Seepage, Lagoon	Fox River
PORTAGE	7822	7800	Municipal	0.741			85		Tr.Filt. (1957)	Fox River
PRINCETON	1509	1500	Municipal	0.288			288		Primary, Chlor.	Fox River
Shield Creamery			Milk						Irrigation	Mecon River

APPENDIX E
USDI - FWPCA
WASTE SOURCES: WISCONSIN
UPPER FOX RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
RANDOLPH	1507	1505	Municipal							Fountain Cr.
Lake Emily Cheese Fact.			Milk						Sep.Tk.	Lake Emily
RIPON	6163	6765	Municipal	0.927			35		Tr. Filt. (1953)	Silver Cr.
Green Giant Co.			Canning						Irrigation, Lagoon	Silver Cr.
ROSENDALE	415		Municipal	0.032					Act.Sludge (1963)	W.Br. Fond du Lac R.
Green Giant Co.			Canning	1.2					Irrigation Lagoon	W.Br. Fond du Lac R.
Rogersville Cheese Fact.			Milk						Ridges & Furrow	W.Br. Fond du Lac R.
SHERWOOD			Municipal						Sep.Tks.	L. Winnebago
STOCKBRIDGE	476		Municipal						Lagoon (1964)	L. Winnebago
TAYCHEEDAH			Municipal						Sep. Tks.	L. Winnebago
St. Marys Springs Academy			Domestic						Act.Sl. (1965)	L. Winnebago

APPENDIX E
USDI - FWPCA
WASTE SOURCES: WISCONSIN
UPPER FOX RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
TAYCHEEDAH (Cont.) Wis. Home for Women			Domestic	0.06			17		Tr. Filt. (1950)	L. Winnebago
WAUTOMA	1466	1450	Municipal	0.37			60		Tr. Filt.	White R.
WESTFIELD	919	900	Municipal	0.09			100		Primary (1958) Chlor.	Westfield Cr
Central Wisconsin Coop. Dairies			Milk						Ridge & Furrow	Westfield Cr

APPENDIX E
USDI - FWPCA
WASTE SOURCES: WISCONSIN

WOLF RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Raw SS	Discharge BOD_5	Discharge SS	Treatment Provided	Receiving Waters
ALMOND	391	390	Municipal						Lagoon	Pine River
AMHERST	596	600	Municipal	0.02			8		Secondary	Tomorrow R.
Borden & Co.			Dairy	0.01					Trick.Filt.	Tomorrow R.
BEAR CREEK	455		Municipal	0.035			8		Secondary	Bear Creek
Flanagan Bros.			Canning	0.1			20		Lagoon	Bear Creek
Riverside Cheese Fac.			Milk						Sep.Tank	Embarass R.
BIRNAMWOOD	568	500	Municipal	0.5			61		Secondary	S.Branch Embarass R.
BLACK CREEK	707	700	Municipal	0.115			16		Secondary	Black Creek
Frank Pure Food Co.			Canning						Lagoon	Black Creek
BONDUEL	876	870	Municipal	0.13			60		Secondary	Bonduel Trib.
Bonduel Pickle Co.			Canning							Bonduel Trib.
CAROLINE										
F.R. Bussy Co.			Milk	0.02	230		230		None	Embarass R.
CECIL	357		Municipal							Pickerel Cr.

APPENDIX E
USDI - FWPCA
WASTE SOURCES: WISCONSIN
WOLF RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Raw SS	Discharge BOD_5	Discharge SS	Treatment Provided	Receiving Waters
CLINTONVILLE	4,778	4,800	Municipal	0.65			100		Secondary	Pigeon R.
Shawano Canning Co.			Canning						Irrigation	Pigeon R.
EMBARASS	306	300	Municipal	0.025			30		Primary	Embarass R.
Matteson Cheese & Butter Co.			Milk						Sep. Tank	Embarass R.
FREMONT	575		Municipal						None	Wolf River
Alder Creek Cheese Fac.			Milk						Hauling & Adsorption	Alder Creek
GUSHAM	458	450	Municipal	0.023			54		Primary	Red River
HORTONVILLE	1,366	1,370	Municipal	0.146			63		Secondary	Blk.Otter Cr.
Fox Valley Canning Co.			Canning						Irrigation	Blk.Otter Cr.
IOLA	831	800	Municipal	0.045			100		Primary	So. Br. Little Wolf R.
KESHEN			Municipal	0.025			7		Secondary	Wolf River

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USDI - FWPCA
WASTE SOURCES: WISCONSIN
WOLF RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
MANAWA	1,037	1,050	Municipal	0.075			120		Primary	No. Br. Little Wolf R.
Little Wolf Rest Home			Domestic						Sep. Tank	No. Br. Little Wolf R.
Symco Cheese Corp.			Milk						Irrigation	No. Br. Little Wolf River
MARION	1,200	1,200	Municipal	0.145			170		Primary	No. Br. Pigeon R.
Quartsline Cheese Fact.			Milk						Irrigation	No. Br. Pigeon R.
NELSONVILLE	170		Municipal							Tomorrow R.
Farmers Coop.			Dairy						Irrigation	Tomorrow R.
NEW LONDON	5,288	5,300	Municipal	0.623			910		Secondary overloaded	Wolf River
NEOPIT	1,359		Municipal	0.05			56		Trick.Filt.	W. Br. Wolf River
Menominee Enterprises			Debarking	0.4					Screening	W. Br. Wolf River
NICHOLS —	150		Municipal	0.038			25		None	Schic R.

APPENDIX E
USDI - FWPCA
WASTE SOURCES: WISCONSIN
WOLF RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Raw SS	Discharge BOD_5	Discharge SS	Treatment Provided	Receiving Waters
POY SIPPI			Municipal							Pine River
Daisy Dairy Co			Milk	0.007			70		Hauling & Adsorption	Pine River
PINE RIVER										Brushville Cr.
Brushville Creek Cheese Fact.			Milk						Hauling & Adsorption	Brushville Cr.
REDGRANITE	588		Municipal	0.035			7		Secondary	Willow Creek
Chicago Pickle Co.			Canning						Irrigation	Trib. #1
Chicago Pickle Co.			Canning						Irrigation	Trib. #2
ROSHOLT	497		Municipal	0.7						Flume Creek
Rosholt Cheese Factory			Milk				100		Hauling & Irrigation	Flume Creek
SCANDANAVIA	266		Municipal							S.Br Little Wolf R.
Scandanavia Cream Corp.			Milk	0.006			70		Sep. Tank	S.Br.Little Wolf R.
SEYMOUR	2,045	2,100	Municipal	0.249			60		Secondary	Black Creek
Seymour Canning Co.			Canning						Irrigation	Black Creek

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USDI - FWPCA
WASTE SOURCES: WISCONSIN

WOLF RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD5	Raw SS	Discharge BOD5	Discharge SS	Treatment Provided	Receiving Waters
SHAWANO	6,130	6,300	Municipal	0.875			433		Secondary	Wolf River
Badger Breeders Coop.			Domestic	0.003			2		Neutralization & Aeration	Wolf River
Shawano Paper Mills			Paper	1.7			400		Savealls	Wolf River
Shawano County Hosp. Home			Domestic	0.006			10		Sep. Tank	Long Lake Cr.
SHIOCTON	685		Municipal	0.065			65		Primary	Wolf River
Shiocton Dairy			Milk						Hauling	Wolf River
Shiocton Kraut Co.									Irrigation	Wolf River
STEVENSVILLE			Municipal							Bear Creek
Stevensville Cheese Fac.			Milk	0.0525			35		Sep. Tank	Bear Creek
TIGERTON	781	750	Municipal	0.035			93		Primary	So. Br. Embarass R.
TOSTIN			Municipal							Poygan Lake

APPENDIX E
USDI - FWPCA
WASTE SOURCES: WISCONSIN

WOLF RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Raw SS	Discharge BOD_5	Discharge SS	Treatment Provided	Receiving Waters
WAUPACA	3,984	4,000	Municipal	0.28			605		Primary	Waupaca R.
Grand Army Home for Vets.			Domestic						Irrigation	So. Br. Waupaca R.
Sherman Cheese & Butter Co.			Milk						Irrigation	Waupaca R.
WEYAUWEGA	1,239	1,250	Municipal	0.202			135		Secondary	Waupaca R.
Weyauwega Dairy			Milk	0.01			15		None	Waupaca R.
WHITE LAKE	325		Municipal							Wolf R.
Wolf River Cheese Fac.			Milk						Irrigation	Wolf R.
Yawkey Bissel			Oil & Boiler							White Lake Creek
WILD ROSE	594									Pine River
Wild Rose Creamery Coop.			Milk						Irrigation	Pine River
Wild Rose Hosp.			Domestic						Adsorption	Pine River
WINNECONNE	1,273	1,275	Municipal	0.6			133		Primary	Wolf River
A&P Tea Co. (White House Milk Div.)			Milk							Wolf River
Winneconne Coop.			Milk						Screen & Irrigation	Wolf River

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WASTE SOURCES: WISCONSIN

WOLF RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
WITTENBERG	892	900	Municipal	0.16			31		Secondary	Tiger Creek

APPENDIX E
USDI - FWPCA
WASTE SOURCES: WISCONSIN
DOOR GROUP

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Raw SS	Discharge BOD_5	Discharge SS	Treatment Provided	Receiving Waters
ALGOMA, City of	3,855	3,800	Municipal	3.22			360		Primary	Ahnapee R.
Algoma Creamery										Ahnapee R.
Alaska Farmers									Sep. Tank	Alaska Lake Creek
Rio Creek Coop. Cheese Fac.			Cheese Factory						None	Rio Creek
BAILEYS HARBOR										
Baileys Harbor Laundry			Laundry	.012			30		Sep. Tank	L. Mich. Door Penin.
CASCO										
Rosiere Coop.			Cheese Factory	.0075			75		Sep. Tank	Broemmers Cr.
FORESTVILLE, Vill.	341	150	Municipal	.035			16		Secondary	Ahnapee R.
STURGEON BAY, City	7,353	6,200	Municipal	7.60	1,770		140		Secondary	Sturgeon Bay Canal

APPENDIX E
USDI - FWPCA
WASTE SOURCES: WISCONSIN
KEWAUNEE RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Raw SS	Discharge BOD_5	Discharge SS	Treatment Provided	Receiving Waters
CASCO, Village of	460	450	Sewage	.107	235		13		Secondary	Casco Cr.
Lake Dairy Coop.			Dairy Wastes	.0151					Secondary	Casco Cr.
KEWAUNEE, City of	2,772	2,780	Sewage	.275			330		Primary	Kewaunee R.
Kewaunee Engr. Corp.			Sewage	.010			17		Sep. Tank & Tile Fld.	Kewaunee R.
LUXEMBURG, Village	730	750	Sewage	.09			22		Secondary	Kewaunee R.
Badger State Cheese Fac.			Cheese Fac. Waste	.009			75		Sep. Tank	Kewaunee R.

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WASTE SOURCES: WISCONSIN
TWIN RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
DENMARK	1,106	1,150	Municipal	.250	750		75		Sec.	Neshota R.
Ellisville Coop Dairy			Dairy						Lagoon	Mishicot R.
Schuster Const.			Gravel Washing	.200					Lagoon	Neshota R.
FRANCIS CREEK	400	150	Municipal	0.10	25		21		Sec.	Neshota R.
Brookside Dairy			Dairy						None	Point Beach
Powell Lesich-ing Cheese Fac.			Cheese Factory							
MISHICOT	762	760	Municipal	.120	150		32		Sec.	Mishicot R.
Foremost Dairies				.140					Sec.	Mishicot R.
Modern Dairy			Dairy	.10					Sep. Tank	Mishicot R.
TWO RIVERS	12,393	12,395	Municipal	2.36	2500		334		Sec.	W. Twin R.
Eggers Plywood & Veneer			Solids, Bark, Etc.						None	W. Twin R.
Hamilton Mfg.			Metal Finishing	.100					None	Mishicot R.
Kornely Dairy			Dairy	0.7					Sep. Tank	Neshota R.
Mirro Mfg. Scool Section			Metal Finishing	.175					None	Neshota R.
Cheese Factory			Cheese Factory						None	W. Twin R.

APPENDIX E
USDI - FWPCA
WASTE SOURCES: WISCONSIN
MANITOWOC RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
BRILLION	1,783	1,785	Municipal	.128	322		32		Secondary	Spring Cr. to N. Br. Manitowoc R.
Calumet-Dutch Packing Co.			Canning						Lagoon	N. Br. Manitowoc R.
CHILTON	2,578	2,580	Municipal		670		67			S. Br. Manitowoc R.
Burton Brook Cheese Fac.			Milk	.003			44		Sep.Tank	S. Br. Manitowoc R.
Carnation Co.			Milk							S. Br. Manitowoc R.
Chilton Canning			Canning							S. Br. Manitowoc R.
Chilton Dairy Produce			Milk	.0028			21			S. Br. Manitowoc R.
Chilton Malting			Malt							S. Br. Manitowoc R.
Garnet Dairy			Milk	.0014			24		Sep.Tank	S. Br. Manitowoc R.
Johnsburg Cheese Factory			Milk	.0025			36			S. Br. Manitowoc R.

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WASTE SOURCES: WISCONSIN
MANITOWOC RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
HILBERT	736	735	Municipal	.038	135		33		Secondary	Hilbert Cr. to N. Br. on Manitowoc R. to Manitowoc River
Cold Spring Cheese Fac.			Milk	.009						N. Br. Manitowoc R.
MANITOWOC	32,275	33,670	Municipal & Ind.	3.58	8000		2,500		Secondary	L. Michigan
Al. Goods Mfg.			Al. Goods						None	Manitowoc R.
Ann Arbor RR			Sewage & Garbage							Manitowoc R.
C & O RR			Sewage & Garbage						None	Manitowoc R.
Heresite & Chem. Co.										Manitowoc R.
Kurth Malting Co.			Malt	.500			1,870		None	Manitowoc R.
Lakeside Pkg.			Canning						Primary	Municipal Sewers
Manitowoc Equip. Wks.			Metal Platers						None	Manitowoc R.

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USDI - FWPCA
WASTE SOURCES: WISCONSIN

MANITOWOC RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Raw SS	Discharge BOD_5	Discharge SS	Treatment Provided	Receiving Waters
MANITOWOC										
Manitowoc Shipbldg. Co.			Shipbuilding	.006/boiler					None	Manitowoc R.
Rahr Malting Co.			Malt	2.89			2,836		Screening	Manitowoc R.
MARYTOWN										
Garnet Dairy										
NEW HOLSTEIN	2,401	2,400	Municipal	.225	1000		335		Secondary	Pine Cr. to S. Br. Manitowoc R.
A.T. Hipke & Sons			Canning	.075			1,250			
POTTER			Municipal						Sep. Tank	N. Br. Manitowoc R.
REEDSVILLE										
Red Clover Cheese Fac.			Milk Wastes	.0022			29		Sep. Tank	Mud Creek

APPENDIX E
USDI - FWPCA
WASTE SOURCES: WISCONSIN

MANITOWOC RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
VALDERS	622	620		.065					Imhoff + Filters	Valders Dit. to Manitowoc River
Heinz Mills Cheese Fac.			Milk	.0032			45		None	Manitowoc R.
Nestles Milk Co.			Milk	.008			35		City Sewers	No. Branch
Valders Canning			Canning	.125					Sep. Tank	

APPENDIX E
USDI - FWPCA
WASTE SOURCES: WISCONSIN
SHEBOYGAN RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Raw SS	Discharge BOD_5	Discharge SS	Treatment Provided	Receiving Waters
BELGIUM, Village	643	645		.036			17		Sec.	Belgium Trib.
Cedar Valley Cheese Fac.			Cheese Factory						Sep. Tank & Lagoon	Sauk Cr.
Fairview Cheese Fac.			Cheese Factory						None	Onion R. Tr.
Krier Preserving Co.			Cannery						Lag.& Irr.	Belgium Tr.
BLACK RIVER, Comm.			Municipal						Private	Black R.
CEDAR GROVE, Vill.	1,175	1,175	Municipal	.100			58		Sec.	Cedar Cr.Tr.
Calumet-Dutch Packing Co.			Cannery						Spray Irr.	Cedar Gr. Tr.
CLEVELAND, Vill.			Municipal							Centerville Cr.
Lake Shore Canning Co.			Cannery						Lagoon	Centerville Cr.
Matthias Dairy			Dairy						Sep. Tank	Trib. of Centerville Cr.
Spring Valley Dairies			Dairy						Sep. Tank	7-mi. Creek
ELKART LAKE, Vill.	651	800	Municipal	.07			222		Sec.	LaBudde Cr.
ERDMAN (unincor.)			Municipal							Pigeon R.

APPENDIX E
USDI - FWPCA
WASTE SOURCES: WISCONSIN
SHEBOYGAN RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
ERDMAN										
Erdman Cheese Factory			Cheese Factory	.0047					Sep. Tank	Pigeon R.
FOND DU LAC										
Tolibia Cheese Mfg. Corp.			Cheese Factory						Lagoon	Sheboygan R.
GIBBSVILLE, Comm.			Municipal						None	Onion R.
GLENBEULAH, Vill.	428	430	Municipal	.055	84		32		Primary	Mullett R.
Glenbeulah Canning Co.			Canning						Irrigation	Mullett R.
HAVEN, Comm. of			Municipal							7-mi. Cr.
HINGHAM, Comm. of			Municipal						None	Onion R.
HOWARDS GROVE										
Millersville San. Dist.			Municipal						Sec.	Pigeon River
KIEL, City of	2,772	2,780	Municipal		715		510		Sec.	Sheboygan R.
KNELLSVILLE										
(unin.)			Municipal						Private	Knellsville Drainage Ditch

APPENDIX E
USDI - FWPCA
WASTE SOURCES: WISCONSIN
SHEBOYGAN RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Raw SS	Discharge BOD_5	Discharge SS	Treatment Provided	Receiving Waters
KOHLER, Vill.	1,524	1,525	Municipal	.742			35		Sec.	Sheboygan R.
Kohler Co.			Elec. Plants & Engines	.25						Sheboygan R.
MANITOWOC										
Pine River Dairy Co.			Dairy						Sep. Tank	Silver Creek
MT. CALVARY										
Forest Spring Cheese Fac.			Cheese Factory	.002			30		Sep. Tank	Trib. of Sheboygan R.
OOSTBURG, Vill.			Municipal	.120			33		Sec.	Black R.
Oostburg Canning Co.			Canning							Black R.
OURTOWN (unin.)									Private	Onion R.
PLYMOUTH, City of	5,128	5,130	Municipal	.910	1,400		117		Sec.	Mullett R.
Bamford Cheese Factory			Cheese Factory	.0108			120		Sep. Tank	Trib. of Sheboygan R.
Crystal Springs Cheese Factory			Cheese Factory	.0036			40		Sep. Tank	Outlet of Marsh
Lakeland College			Municipal	.02			4		Sec.	Fisher Cr. Trib.

APPENDIX E
USDI - FWPCA
WASTE SOURCES: WISCONSIN
SHEBOYGAN RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
PLYMOUTH										
Plymouth Ind. Prod. Co.										Mullett R.
Stokely-Van Camp			Canning Wastes						Irrig.	Mullett R.
PORT WASHINGTON	5,934	5,985	Municipal	.900	1,670		667		Primary	L. Mich.
Edgewater Power Plant			Elec. Gen.	20					Lagoon	
Highway 29 Cheese Fac.			Cheese Factory	.003			40		Sep. Tank	Tributary
Port Country Club			Municipal						Sep. Tank	Port Country Club Trib.
SHEBOYGAN	45,747	45,950	Municipal, Indus.	9	10,350		2,077		Secondary	L. Mich.
Storm Sewer			BOD of over 80 mg/l	.64					None	Sheboygan Storm Sewer
Empire Petroleum Co.			Oil Refinery						Lagoons	Fish Creek
Lakeside Coop. Cheese Assoc.			Cheese Factory	.004			46		Septic T.	Trib. Black River
Sheboygan County Hospital	250	256	Hospital			42	8		Sec.	Trib.
Verifine Dairy			Dairy						None	Main Stem
Wis. Elec. Power			Elec. Gen.	720						L. Mich.

APPENDIX E
USDI - FWPCA
WASTE SOURCES: WISCONSIN
SHEBOYGAN RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Raw SS	Discharge BOD_5	Discharge SS	Treatment Provided	Receiving Waters
SHEBOYGAN FALLS	4,061	4,060	Municipal	.51			400		Sec.	Sheboygan R.
Elm Grove Cheese Fac.			Cheese Factory							
Gibbsville Cheese Fac.			Cheese Factory						Irrig.	Onion R.
A.J.Hanford Cheese Fac.			Cheese Factory						Sep. Tank	Trib.
Richardson Bros.			Sanitary						None	Mullett R.
Richardson Sub-div. (Mill Road Water Coop.)			Municipal	.008			10		Primary	Sheboygan R..
SPRING VALLEY										
Spring Valley Cheese Fac.			Cheese Factory	.0067			28			Meeme R.
WALDO, Vill.	403		Municipal							Onion R.
Calumet-Dutch Packing Co.			Cannery						Lagoon	Waldo Ditch
Waldo Canning Co.			Cannery							Onion R.
Waldo Cheese Fac.			Cheese Factory							Onion R.

APPENDIX E
USDI - FWPCA
WASTE SOURCES: WISCONSIN
LAKE MICHIGAN DRAINAGE BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD5	Raw SS	Discharge BOD5	Discharge SS	Treatment Provided	Receiving Waters
CAMPBELLSPORT	1,472	1.470	Municipal	.2			200		Act.Sludge	Milwaukee R.
CARROLLVILLE	1,250	1,250	Municipal	0.12					Primary	L. Mich.
Milwaukee Met. Sew. Comm.			Domestic						Primary	L. Mich.
Peter Coop.Corp.			Glue						Primary	L. Mich.
CEDARBURG	5,191	5,190	Domestic	.8			59		Secondary	Cedar Grove Cr.toL.Mich.
FREDONIA	710		Sewage				54		Secondary	Milwaukee R.
GERMANTOWN	622	620	Sewage	.21			167		Secondary	
GRAFTON	3,748	3,750	Sewage	.28			66		Secondary	Milwaukee R.
JACKSON	458	460	Sewage	.054			17		Secondary	Cedar Cr. to Milwaukee R.
KENOSHA	67,899	70,000	Municipal-Comb. Sewers						Primary	L. Mich.
Am. Motors			Industrial						Sedim.	L. Mich.
Anaconda Am. Brass			Acids						Neutral.	L. Mich.
KEWASKUM	1,572	1,570	Sewage	.25			167		Secondary	Milwaukee R.

APPENDIX E
USDI - FWPCA
WASTE SOURCES: WISCONSIN

LAKE MICHIGAN DRAINAGE BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
MENOMONEE FALLS	18,276	8,000	Municipal	0.56					Secondary	Milwaukee R.
MEQUON										
Chalet on Lake	200	200	Municipal						Primary Chlorin.	L. Michigan
Sisters of Notre Dame on Lake			Domestic						Aeration	L. Michigan
MILWAUKEE	741,324									
Milwaukee Metro. S.D.		967,700	Municipal-Combined Sewers	187.3					Act.Sludge	L. Michigan
C&NW RR Yards			Oils						Set.Lagoon	Milwaukee R.
Cities Service Oil Co.			Refinery						None	Milwaukee R.
CM&StP&P RR Yds.			Oils						Settling	Milwaukee R.
Crucible Steel Casting Co.			Metals						Settling	Kinnickinnac River
Delta Oil Co.			Refinery						None	Milwaukee R.
Evinrude Motors			Industrial						Settling	Milwaukee R.
Falk Corp.			Metals						Settling	Milwaukee R.
Globe Steel Tubing			Metals						Settling	Milwaukee R.
Heil Co.			Metals						Settling	Milwaukee R.

APPENDIX E
USDI - FWPCA
WASTE SOURCES: WISCONSIN

LAKE MICHIGAN DRAINAGE BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
MILWAUKEE										
Highway Pavers			Metals						None	Milwaukee R.
Inland Steel			Metals						Settling	Milwaukee R.
International Harvester Co.			Metals						Settling	Milwaukee R.
Interstate Drop Forge Co.			Metals						Settling	Milwaukee R.
Maynard Steel Casting Co.			Metals						Settling	Milwaukee R.
Milwaukee Stone & Marble Co.			Stone						Settling	Milwaukee R.
Rundle Mfg. Co.									None	Milwaukee R.
Seaman Body, Div. of Am. Motors			Oils						Settling	Milwaukee R.
A.O. Smith Co.			Metals						Settling	Milwaukee R.
State Fair Grds.			Domestic						Sep.Tank	Honey Creek
Tanners Prod.Co.			Tanning						Primary	Milwaukee R.
Vihlein Co.									Settling	Milwaukee R.
Woddhams Oil Co.			Oil						None	Milwaukee R.
Wisconsin Bridge & Iron Co.			Metals						Settling	Milwaukee R.
RACINE (See Root River Basin)										
North Park S.D.	2,200		Municipal	0.2					Trick.Filt. Chlorin.	L. Michigan

APPENDIX E
USDI - FWPCA
WASTE SOURCES: WISCONSIN
LAKE MICHIGAN DRAINAGE BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
SAUKVILLE	1,038	1,040	Domestic	.18			60		Secondary	Milwaukee R.
SO. MILWAUKEE	20,307		Municipal						Primary Chlorin.	L. Michigan
THIENSVILLE	2,507	3,405	Sewage	.56			168		Secondary	Milwaukee R.
WEST BEND	11,538	11,740	Sewage & Ind. W.	1.431			467		Secondary	Milwaukee R.

APPENDIX E
USDI - FWPCA
WASTE SOURCES: WISCONSIN
ROOT RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD5	Raw SS	Discharge BOD5	Discharge SS	Treatment Provided	Receiving Waters
CADDY VISTA Subd.	1,200	1,200	Municipal	0.07					Trick.Filt. (1955)	Root R.
CALEDONIA			Municipal	0.64			288		Act. Sl. & Trick. Filt.	L. Mich.
Fohrs Meat Serv.			Meat Processing	0.003			35		Sep. Tank	Root R.
FRANKLIN SD #1		240	Municipal	0.04			12		Trick.Filt.	Root R.
Country Dale School			Domestic	0.003			7		Sep. Tank	Tess Corners Creek
Highway 100 Drive-In Th.			Domestic						Sep. Tank & Lagoon	Marsh
Milwaukee House of Correction	1,150		Domestic	0.10			20		Trick.Filt.	Root R.
Pure Oil Co.				0.007			2		Act. Sludge Chlor.	Root R.
FRANKSVILLE										
C & D Duck Co.			Duck Slaughtering						Lagoon & Spray Irr.	Root R.
Frank Pure Food Co.			Sauerkraut						Lagoons	Hoods Cr.
Harry Hansen Meat Service			Meat Processing	0.003			40		Sep. Tank & Leach Bds.	Root R.
Racine Co. Highway & Office Bldg.			Domestic	0.004			1		Act. Sludge & Lagoon	Hoods Creek

APPENDIX E
USDI - FWPCA
WASTE SOURCES: WISCONSIN

ROOT RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Raw SS	Discharge BOD_5	Discharge SS	Treatment Provided	Receiving Waters
FRANKSVILLE										
York Duck Co.			Duck Raising						Lagoons	Root River
GREENDALE	6,843		Municipal	0.675			300		Act. Sludge Lagoon	Root River
GREEN RIDGE Subd.			Municipal	0.0016			2		Act. Sludge (1967)	Root River
HALES CORNERS	5,549	5,000	Municipal	0.779			210		Trick. Filt.	Root River
MUSKEGON										
Boldts, Inc.			NH_3; Sus. Solids					2820	None	Root River
OAK CREEK										
Power Plant			Dom., Cooling Water & Sus. Solids	0.0155					Dom-Act. Sludge Ind-Ion Ex. Settling	L. Mich.
OAKVIEW Subd.#3			Municipal	0.03					Lagoon	L. Mich.

APPENDIX E
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WASTE SOURCES: WISCONSIN

ROOT RIVER BASIN

Community or Industry	Population (1960)	Population Served	Type of Waste Critical Constituents	Waste Flow MGD	Waste (lbs/day) Raw BOD_5	Waste (lbs/day) Raw SS	Waste (lbs/day) Discharge BOD_5	Waste (lbs/day) Discharge SS	Treatment Provided	Receiving Waters
RACINE	89,144		Mun.&Comb. Sewers	18.75			13,000		Primary	L. Mich.
J. I. Case			Foundry washes					2,592	None	L. Mich.
Shepard Plating Co.			Plating washes (cyanide & chrom.)	0.015					None	Root R.
ROOT RIVER HEIGHTS Subdivision			Municipal						Act.Sludge (1967) & Lagoon	Root R.
TESS CORNERS (Muskego, Wis.)			Municipal						Sep. Tanks	Root R.
Tess Corners School									Sep. Tanks Filter	Root R.
UNION GROVE	1,970	2,200	Municipal	0.39					Act.Sludge	Root R.
Casey's Locker & Meat Serv.			Meat processing	0.001			10		Sep. Tank	Root R.
Southern Colony & Train. Sch.			Domestic	0.320			75		Act.Sludge	Root R.

MR. SCHNEIDER: Referring to page 67 of the Report, there are three specific recommendations for municipalities which are coded to the needs of each, depending upon the existing degree of treatment and the existence of combined sewers. These recommendations provide for upgrading of existing primary and secondary facilities to advanced waste treatment by 1972 and for substantial elimination of pollution from combined sewers by 1977. In order to attack the major portion of the municipal waste input, it was considered that municipalities of roughly 5,000 population and over should provide advanced waste treatment.

In the case of industries, information was not sufficient to apply the same degree of specificity as for municipalities. Rather, it is recommended that the needs for the listed industries be determined by the State water pollution control agencies within six months of the issuance of the conference summary and construction of necessary facilities be completed within 36 months.

Since these specific recommendations

are part of the Report which has been made available for general distribution, I will not repeat them here, but as Chairman Stein indicated, our attention has been called to some of the omissions from the list of the Report and we will take care of those as he suggested.

To summarize the reports that have been presented, the information has shown that varying degrees of pollution now exist in the inshore waters of the lake and on the major tributary streams. The report on eutrophication has shown that there is an accelerating buildup of fertilizing material in the lake water which stimulates excessive aquatic growths and which poses a threat to the lake now in localized areas, and to the lake as a whole in the future. The report on lake currents has shown that what happens on one part of the lake eventually affects all parts of the lake. The conclusions and recommendations reflect a sense of urgent concern for preserving and enhancing the quality of Lake Michigan and tributary streams. We have recommended

upgrading of treatment facilities, to secondary treatment and phosphate removal in all cases, and to a higher degree of treatment than is now conventionally accepted as adequate in specific instances. The report on advanced waste treatment has shown that technically feasible methods exist for such treatment. It also shows that the cost will be higher than we have been accustomed to in the past. We have also tried to show that the need for a clean lake is and will be so great that we cannot afford not to abate all known sources of pollution to the maximum possible extent.

MR. STEIN: Does that conclude it?

MR. SCHNEIDER: Yes, sir.

MR. STEIN: I don't know whether the conferees want to comment now or take these under advisement and take them up later.

MR. HOLMER: We face the problem, Mr. Chairman, that this afternoon would not be nearly long enough, I am sure, for us to satisfy ourselves.

MR. STEIN: I think so. These things

are well written, clearly written and well stated. My suggestion is we possibly can have the conferees consider these and take these up at a later time when they have more time for the discussion on this, because otherwise we are going to run over-time and we probably can best utilize this time between now and 5 o'clock by listening to another presentation.

What do you think of that? I think that would be best.

Thank you very much, Mr. Schneider, for your report.

Mr. Poston.

MR. POSTON: I indicated to Mr. Carbine, Regional Director for the Great Lakes Region of the Bureau of Commercial Fisheries, that he might make his statement this evening in view of the fact that he must leave and would not be able to do this tomorrow. Since Mr. Carbine has important information on the alewife problem, I thought it best that he deliver this himself.

MR. KLASSEN: Mr. Chairman, may I

just raise a point before we go on?

MR. STEIN: Yes.

MR. KLASSEN: You say we are going to consider these recommendations later, which is all right with me. I have some comments I want to make on them. But I would like a copy of what was read in the recommendations as he read them, because he made some changes that are not in this text that you furnished us. I would like by tomorrow to have a copy of what he read, because, as I indicated, he has made some changes that do not appear in this written or this printed report.

MR. STEIN: Before we go on, Mr. Schneider, are you here?

Would you please come up to the lectern. Did you mark your copy with the changes?

MR. SCHNEIDER: There was a paper passed out, Mr. Klassen, that--

MR. POSTON: I don't think we got that.

MR. KLASSEN: With new recommendations?

MR. SCHNEIDER: Yes, sir, the way I

gave them.

MR. STEIN: Well, the point is, whether it was passed out or not, will you see that we, the conferees, have copies of the paper that you attached to the recommendations and conclusions as you read them?

MR. SCHNEIDER: Certainly.

MR. STEIN: By early tomorrow morning.

MR. KLASSEN: I want to raise this point. Have any of the other conferees not received this? I didn't get it.

MR. HOLMER: I got it.

MR. KLASSEN: I think this is an important point.

MR. STEIN: Let me go off the record for just one moment. I think there is a little confusion.

(Off the record.)

MR. STEIN: We are back on the record.

Mr. Carbine.

W. F. CARBINE

STATEMENT BY W. F. CARBINE
REGIONAL DIRECTOR, GREAT LAKES-CENTRAL REGION
BUREAU OF COMMERCIAL FISHERIES
U. S. DEPARTMENT OF THE INTERIOR

MR. CARBINE: Thank you very much, Mr. Chairman, conferees, ladies and gentlemen.

I have already given the stenographer a copy of my statement, and I hope that you have been given copies also.

I am representing the Bureau of Commercial Fisheries, Department of Interior.

Safeguarding and perpetuating the fishery resources of the Great Lakes are major responsibilities of the U. S. Fish and Wildlife Service and its Bureaus of Commercial Fisheries and Sport Fisheries and Wildlife. Any practice or series of events which threatens the abundance of fish or a useful and productive balance of fish species is of primary concern to us.

Scientists of the Bureau of Commercial Fisheries have been working with the fisheries of the Great Lakes and their environment over

a period of almost 50 years. The Bureau has been in a particularly advantageous position to observe the process of change that has been taking place in this--the largest complex of freshwater resources in the world. We were the first to direct public attention to the now well-publicized deterioration of Lake Erie.

And I might add at this time that this caused a great deal of consternation and a great deal of trouble to me personally. Several States bordering Lake Erie refused to believe that Lake Erie was polluted, and this was just six years ago, but they have since come around. Much of this statement that I will read today has been based and has been suitably updated, of course, on a presentation that was given to the Federal Water Pollution Control Administration sometime ago for their Lake Michigan report.

At the invitation of the Federal Water Pollution Control Administration, the Bureau of Commercial Fisheries has actively participated in review of water quality standards proposed by the States as required by the Water

Quality Act of 1965. This included consideration of the proposed standards for Lake Michigan and its tributaries.

Fish and aquatic life play a unique role with respect to water quality problems, particularly in large and complex ecosystems as represented by the Great Lakes. Long before water quality changes are detectable in gross forms and result in closed beaches and unacceptable domestic water supplies, the interactions among life of the lake can reveal the significance and rate of these changes, thus giving early warning of the need for remedial action.

A brief summary of the changes of fish populations in Lake Michigan forms an instructive background to understand what is happening to the lake and may indicate what should be done. Knowledge of these changes depends on analysis of commercial catch statistics which for most species go back to 1879, interpreted and expanded by direct sampling of fish stocks by Bureau scientists and other investigators.

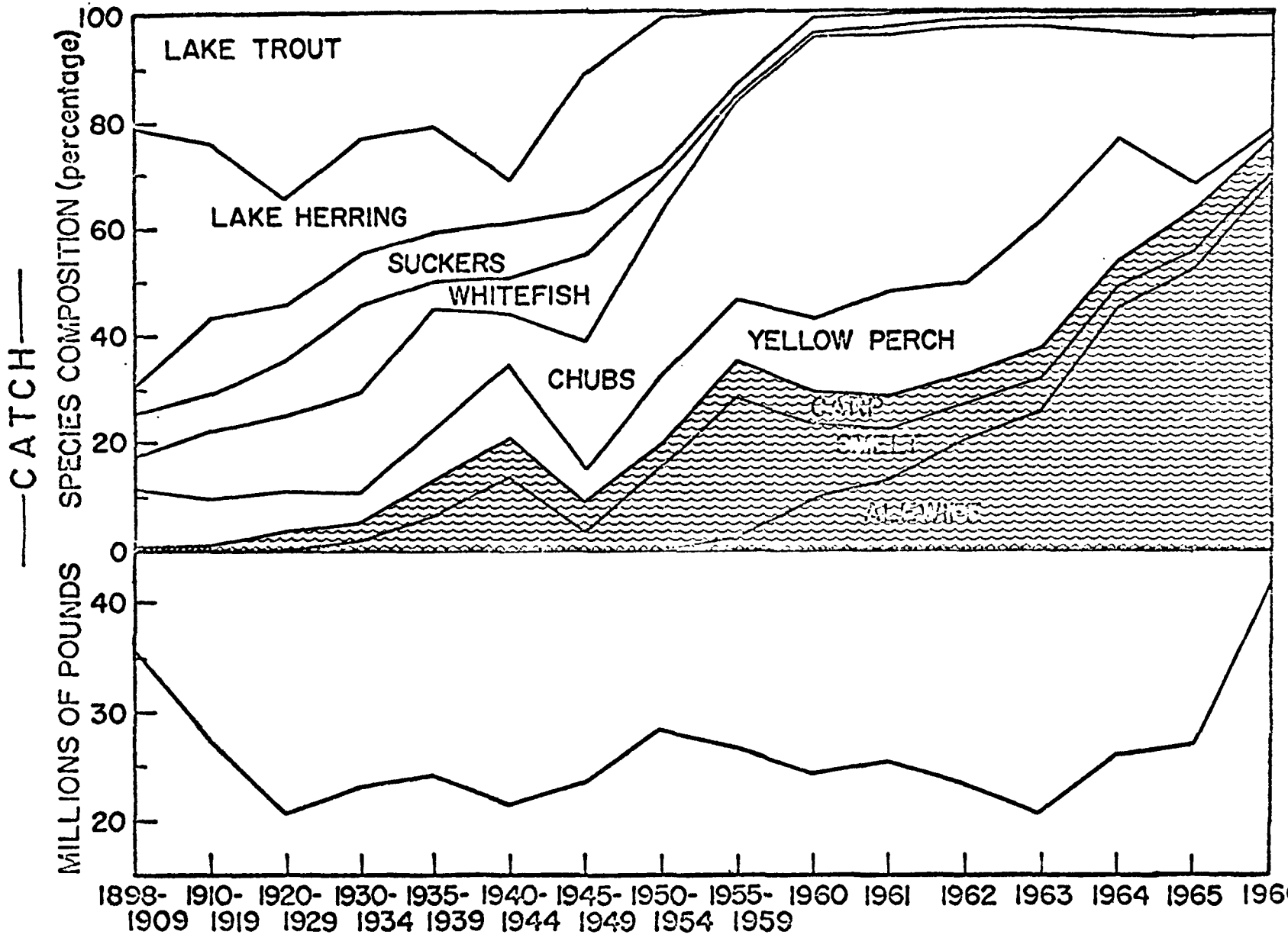
The reason we cannot quote sport

fishery statistics is because no data are available.

Few of the approximately 100 species in Lake Michigan have contributed heavily to the commercial fishery since the first catch statistics were recorded. Only 11 species have contributed 1,000,000 pounds or more annually at one time or another. Eight of the eleven (sturgeon, lake trout, suckers, whitefish, lake herring, walleye, chubs, and yellow perch) are native; three (carp, smelt and alewife) are exotics.

The history of the fishery in Lake Michigan has been typical of the other Great Lakes. The highest annual production occurred near or before the turn of the century when the fishery had become well established. The catch exceeded 40 million pounds in 4 of the 13 years for which statistics were available between 1897 and 1909, and averaged 35 million pounds. In subsequent periods the total catch showed no major variations or trends (Figure 1) and averaged about 25 million pounds until 1966 when the catch increased sharply to over 42

FIG. 1 - COMMERCIAL CATCH-LAKE MICHIGAN



1066

million pounds due primarily to a greater catch of alewives. Nine species have been major contributors to the catch since 1930; they have constituted 95.6 to 99.8 percent of the catch in periods for which records of all species are complete.

At the turn of the century seven major species were represented in the catch (Figure 1). The lake trout and lake herring were the largest contributors, and the carp, which was introduced into the lake in the late 1800's, constituted less than 1 percent of the catch. Despite increased abundance of carp and the subsequent introduction and establishment of the smelt, the relative contribution of the native species to the catch showed no major changes or trends until the 1945-49 period when the lake trout catch declined sharply. Subsequent species changes took place in swift succession (Figure 1). In 1966, the catch was dominated by the alewife which invaded the lake in the late 1940's. In fact, it was recorded first from Lake Michigan in 1949. Exotic species constituted nearly 77 percent

of the catch; and the portion of the catch composed of lake trout, lake herring, suckers, and whitefish was only 4.4 percent as compared with more than 82 percent in the 1898-1909 period.

Several factors contributed to this extreme change, and the interaction of these factors and the exact mechanisms that brought about the change are incompletely understood. There is no question, however, that predation of the sea lamprey triggered the decline of the lake trout in the upper three Great Lakes, and that the resultant pressures of a shifting fishery, and a population explosion of the alewife were major contributing factors.

The importance of interaction between the commercial fishery pressures and biological influences on the fish stocks is quite obvious. What then may be said of the influence of environmental factors (specifically water quality changes) which are the chief interest of this conference? Unfortunately, information is lacking on water quality changes of Lake Michigan over the years comparable to the commercial

fishery statistics which serve as indicators of changes in the fish stocks. Significant but subtle changes in water quality were measured, however, and have had a strong impact or resulted in less conspicuous but equally dramatic biological occurrences such as influences of the sea lamprey and alewife invasions. There is sufficient information to form a reasoned judgment and to guide decisions for future management.

Although Lake Michigan is a single ecosystem in an overall sense, a distinction must be made between the inshore waters and the open lake, both from the fisheries and water quality standpoint. Carp, suckers, yellow perch, walleye, whitefish and lake herring are closely associated with the inshore habitat, and this is where large quantities of the dominant alewife population congregate during late spring and early summer to spawn. This is also the area where pollution is readily observable to eye and nose. Recent studies by the Federal Water Pollution Control Administration have demonstrated increasing

enrichment in this inshore area. Dense quantities of the green algae Cladaphora blanket areas that formerly were devoid of this algae which requires high concentrations of nutrients. There is no question that this enrichment has influenced the inshore species complex, favoring species like the carp, suckers and alewives which have been increasing sharply. Such enrichment has contributed to the decline of the whitefish during the last century in tributaries of Green Bay and during this century in southern Green Bay, Traverse Bay, and southern Lake Michigan. The same enrichment has influenced the decline of the lake herring in southern Green Bay and southern Lake Michigan in this century. The alewife explosion, by creating a population that ranges over the entire lake, has become a mechanism for cycling inshore enrichment throughout the entire lake. The extreme abundance of the alewife, which gets its early start in life in the inshore area, can be attributed to this enrichment.

What of the water of the open lake

and its relation to fish and aquatic organisms? This is the zone normally characterized by a fishery complex consisting of smelt, chubs, lake trout, and the alewife during fall, winter and spring. Figure 2 shows trends in the average concentrations of certain major ions in Lake Michigan waters and the percentage change since 1870. Only three curves are shown, those for sulphate, chloride, and total dissolved solids, since these are the only substances for which dependable, standardized measurements are available over an extended period. There are many other contaminants which influence more strongly the fish and aquatic life in much lower concentrations, but for which similar curves cannot be drawn due to technical limitations and lack of earlier measurements. The trends exhibited in Figure 2 are broadly representative of what is happening to the concentrations of many (though by no means all) other chemical substances. These trends may be summarized as steady increases similar to those before sharp increases took place in Lake Erie in

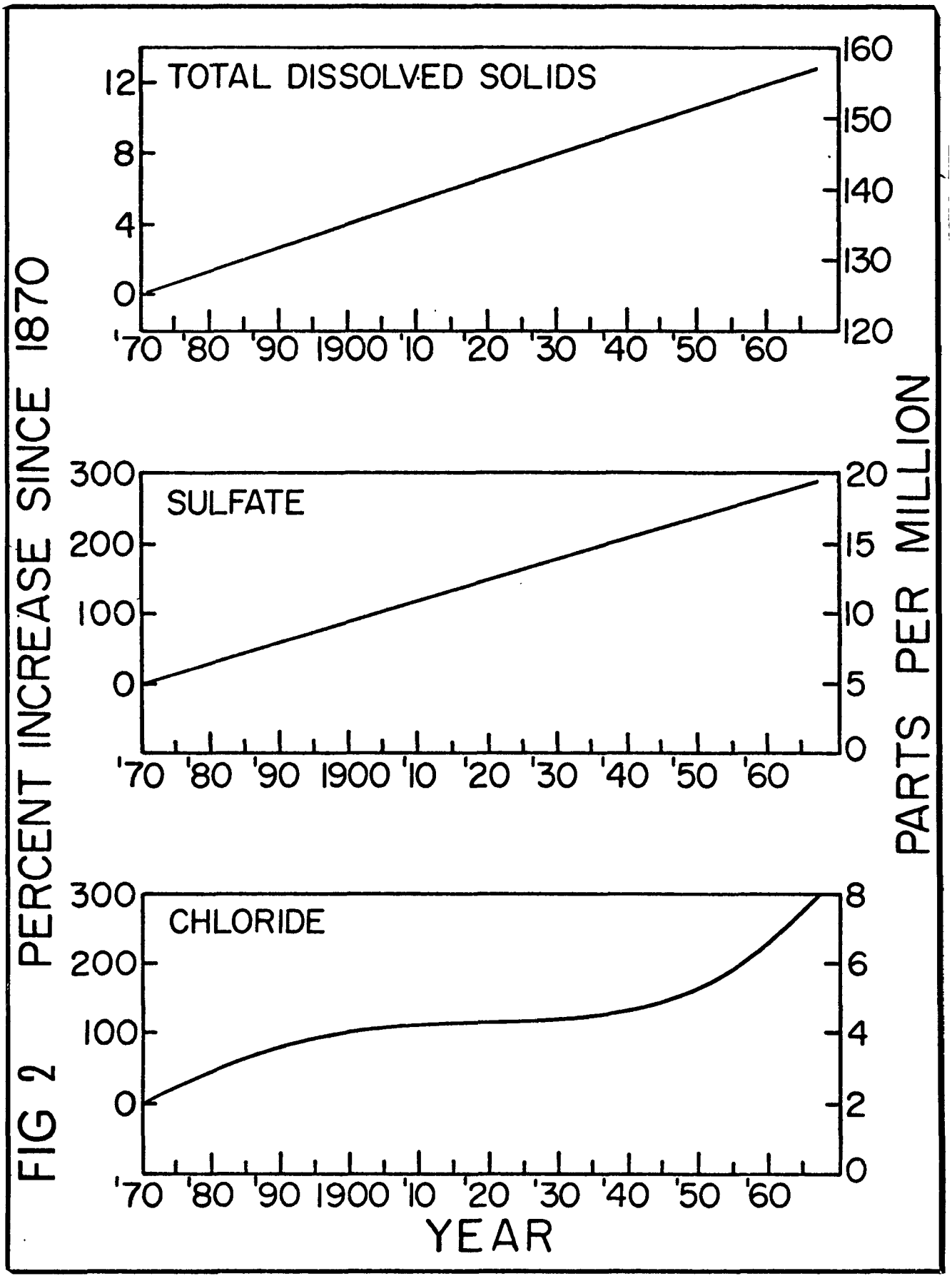

TOTAL DISSOLVED SOLIDS
12
8
4
0
160
150
140
130
120
'70 '80 '90 1900 '10 '20 '30 '40 '50 '60
SULFATE
300
200
100
0
20
15
10
5
0
'70 '80 '90 1900 '10 '20 '30 '40 '50 '60
CHLORIDE
300
200
100
0
8
6
4
2
0
'70 '80 '90 1900 '10 '20 '30 '40 '50 '60
YEAR
PERCENT INCREASE SINCE 1870
PARTS PER MILLION

FIG 2

recent years. Concentrations of several major ions and total dissolved solids in Lake Erie showed a marked acceleration from about the 1930's until the present. The levels of sulfate and total dissolved solids in Lake Michigan are now the same as they were in Lake Erie during the mid-1930's. A similar, sudden acceleration in Lake Michigan will occur unless immediate corrective measures are instituted. For example, chlorides increased two parts per million during 1905 to 1955, a period of 50 years, but required only 12 additional years, 1955 to 1967, to increase two parts per million again. The large volume of Lake Michigan water may have tended to slow the onset of an accelerated buildup as in Lake Erie; but because of the low flushing rate of Lake Michigan, accelerated changes will be irreversible unless drastic remedial action is instituted now.

Although the trends depicted in Figure 2 reflect what is happening for many substances entering the open waters of Lake Michigan, these trends are not necessarily

applicable for all substances. This is particularly true where massive infusions from new pollution sources are a relatively recent development. An example would be the introduction of detergents with consequent increase in release of phosphorus. Phosphorus and nitrogen are key substances capable of triggering many adverse biological effects in the Lake Michigan ecosystem if permitted to accumulate to excess. Only partial long-range data are available to indicate trends in their concentration because of a lack of comparability in analytical techniques between earlier measurements and current procedures. Because of the rapid increase of Cladaphora, it appears however, that these two chemicals are at the point of exponential increase.

Pesticides, herbicides and related chemicals represent another area of water quality change of major importance to fish and aquatic life. At present, Lake Michigan has the highest concentration of pesticides of any of the Great Lakes, which now are only slightly below levels that are known to be injurious to man or aquatic

life. Studies have not been conducted long enough to know if these levels are increasing in the lake, but much higher concentrations are found in many of the tributary streams and increases in the open lake are very likely. The higher concentrations in streams result in higher pesticide accumulation in the tissues of those lake-dwelling fish such as coho salmon which live in streams for a portion of their lives. The current levels of pesticides and related chemicals must be viewed as extremely tenuous. A continuation at high levels or an upsurge in pesticide application anywhere in the Lake Michigan Basin could increase the pesticide concentration prevailing in the open lake from the present non-lethal level to a lethal value.

In both our 1966 Lake Michigan report and our 1967 Lake Erie report, the role of the bottom sediments in any consideration of water quality was stressed. Additional work by our scientists since has strongly reenforced this initial assessment and it should be restated at this conference.

W. F. CARBINE

Much has been said about accelerated eutrophication or aging of the Great Lakes. In the public's mind, this tends to be viewed as a direct relationship between overenrichment through man's activity, translated into overstimulation of plant and algal growth, with consequent adverse effects such as depletion of oxygen during stratification. This phenomenon is indeed a factor; but if it were the only one, simple shutting off of the nutrient sources would result in rapid improvement. The actual situation is much more complex and more difficult to solve. The evidence indicates that, besides the well known enriching agents of nitrogen and phosphorus, suspended as well as dissolved solids, undecomposed organic material, and a long list of chemical elements and compounds that have been incorporated in the bottom sediments pose a real threat. Under stratified conditions, this accumulative mass, working through an incredibly complex series of chemical reactions, robs the oxygen over hundreds of square miles of Lake Erie bottom. Recent work by our

scientists studying Lake Erie indicates that under these anaerobic conditions, higher concentrations of many dissolved chemical elements and compounds in the deeper waters are drawn from accumulated residues in the bottom sediments. Continuing work will trace what happens when stratification is broken up and oxygen returns temporarily to the deeper water of the lake. It seems very likely that the substances in the super-saturated dissolved condition then precipitate to re-enter the sediments, thus becoming available to begin the same vicious cycle all over. Should this be true,man may be confronted with a self-perpetuating situation partly immune to active flushing action of Lake Erie--to say nothing of Lake Michigan which lacks flushing capability.

These problems caused by the bottom sediments of Lake Erie have been thoroughly documented by Bureau scientists and other workers, and the ramifications to fish and other aquatic life have been well demonstrated. Work on the bottom sediments of Lake Michigan

has not been carried out to the same extent. From the still flourishing conditions of the bottom fauna over most of Lake Michigan, it is obvious that the process has not reached the critical stage that now prevails in Lake Erie. Although the critical level has not as yet been attained in the open waters of Lake Michigan, subtle indicators show that it may be near.

Accelerated research leading to a better understanding of what is happening in the bottom sediments of all the Great Lakes is an obvious necessity to determine measures needed to correct the problem on Lake Erie and prevent a similar problem in Lake Michigan. This must be accompanied by equivalent acceleration of research on the fish and aquatic life. These resources, which are the first to feel the impact of water quality changes, will also be the first to give an indication of success of corrective measures.

In summary, what do we have in Lake Michigan and its aquatic life with respect to water quality, and where can we

go from here? First, we have large segments of the inshore waters that have reached an obvious point of degradation. Second, the open waters of Lake Michigan are in serious danger of degradation resulting from enrichment of the inshore waters. Third, we have clear-cut evidence that concentrations of certain dissolved solids have started to increase sharply as they did in Lake Erie only a few years ago, and evidence that exponential increase may have already begun for other more lethal substances. Fourth, undesirable changes will be accumulative, irreversible, and the rate of increase will intensify rapidly because the lake is not flushed effectively. Fifth, the fish population is extremely unstable and dominated by the alewife which has transferred inshore enrichment throughout the entire ecosystem with a rapidity never possible before. Last, there are many changes in the plankton, benthos, and fish of Lake Michigan which are indicators of detrimental environmental alteration. The sum of these indicators can

lead only to the conclusion that unless immediate measures are implemented to reduce enrichment of Lake Michigan, the deterioration will progress with increased rapidity and conditions will soon be comparable to Lake Erie.

Finally, we come to the really over-riding question--what should be done? Scientists of the Bureau of Commercial Fisheries were perhaps the first to draw attention to the plight of Lake Erie to an apathetic public. It is certain that the sum total of all the available evidence indicates that Lake Michigan is undergoing undesirable changes and that these changes are in the direction of rapid eutrophication, with all that entails in view of Lake Erie's experience.

The biological, aesthetic, and recreational value of Lake Michigan--the largest freshwater resource that lies entirely within the United States--is threatened with swift and early disaster. The indicators that trouble has started are clearly evident when related to what we have learned from experience on Lake Erie. Lake Michigan is different, however, as it is not flushed with one of the

largest rivers of the world that originates from Lake Huron, a vast source of water that is still relatively clean. Lake Michigan, in fact, is not flushed as it has no river flowing through it, but is fed only from tributaries distributed around its drainage that have water richer than the lake itself. With maximum treatment of industrial and domestic wastes, effluent water will be far richer than the lake, and even with complete diversion of industrial and domestic wastes the land drainage will be richer than the lake.

Thus the only hope to save Lake Michigan as a valuable freshwater resource for all uses is to institute immediately a program to treat all wastes to the highest degree possible as a stopgap measure. Ultimately all wastes must be diverted from the drainage, then hopefully, the natural enrichment from land drainage will be low enough so that biological processes in the lake can accomodate it, and the eutrophication of the lake will revert to a slow and natural rate that will not endanger the resources in the generations

to come.

I thank you.

MR. STEIN: Thank you, Mr. Carbine.

(Applause.)

MR. CARBINE: Mr. Chairman.

MR. STEIN: Yes.

MR. CARBINE: Mr. Premetz is available to give you a brief summary of the alewife situation, if you are interested, or if you have time. It will take about 10 minutes.

MR. STEIN: Let's see what our time situation is, Mr. Carbine.

Mr. Carbine, as you can appreciate from his paper, has long been a fisheries expert in the Great Lakes region. I have admired his work a long time before we were members of the Department of Interior and we are happy to be in there now with him.

Are there any comments or questions?

Yes, sir.

MR. KLASSEN: I have two short questions only to better understand this report.

On page 728, the statement, "At present, Lake Michigan has the highest

concentration of pesticides of any of the Great Lakes." I would like to ask whether every other one of the Great Lakes have been studied to the same degree and for the same length of time as Lake Michigan in order to make this comparison?

MR. CARBINE: For the same length of time, yes. We have a number of people working on this. Perhaps we have more samples from Lake Erie than we have from Lake Michigan, but we have studied all of the lakes and these data do indicate that Lake Michigan has the highest pesticide concentration.

MR. KLASSEN: Thank you.

Just one other question then.

On page 1078 could you give me one or two examples of a subtle indicator? What is that?

MR. CARBINE: These changes in the fish populations, for example, you might think that just because a fish is introduced into the lake and it does real well that this is a natural thing due to being in a

new habitat, but the increases in some of the introduced fish, the disappearance of the old fish, these are subtle indicators. We have nothing to prove why they have disappeared.

MR. KLASSEN: Thank you.

MR. STEIN: Are there any further comments?

Mr. Poole.

MR. POOLE: Mr. Carbine, you referred on two or three occasions to the alewife as transferring inshore enrichment throughout the lake. Now, as I recall, earlier in the day someone asked Dr. Bartsch the question did he consider the alewives a factor in transferring phosphorus throughout the lake, and I don't believe I got a clean-cut answer from him. Are you implying by these statements that it is instrumental in a transfer of the phosphorus?

MR. CARBINE: Well, some, yes. But other nutrients, all nutrients, in fact.

The alewife is the only species of fish that we have in the Great Lakes that occupies every niche from the shore to the

deepest of the water, and it occupies these areas at different times of the year. It spawns in the shallow waters, even in the streams, and the buildup of its body, and so forth, takes nutrients, and these in turn are carried out into the deeper waters of the lake, and they occupy the deep waters in the winter and they come up gradually in the shallow water in the spring. So they have this tendency to spread nutrients all over the lake. This is something we have never experienced before.

MR. POOLE: Thank you.

MR. STEIN: Are there any other comments or questions?

MR. HOLMER: I have one other question.

I am, of course, struck by the concluding paragraph of this statement, the first sentence of which says, "Thus the only hope to save Lake Michigan as a valuable freshwater resource for all uses is to institute immediately a program to treat all wastes to the highest degree possible as a stop-gap measure. Ultimately all wastes must be diverted from the drainage."

The question which occurs to me is, having read the forecasts of water consumption in the United States and in these Lake Michigan States would suggest that the total consumption of water for industry and for municipal use would result in the diversion of a rather substantial portion of Lake Michigan and whether this would not contribute to further and more rapid deterioration of the Lake by taking more and more water out of it.

MR. CARBINE: I am not concerned about that as much as I am about the nutrients, sir. All I am interested in is not building up the nutrients in the lake. How this is going to be done, I don't care. It can be done maybe in a treatment facility or maybe it should be pumped out on the land. I don't know how it should be done.

All I have got to say is we can't afford to build up the nutrients any longer in the lake, and this is the only thing that came to our mind. We are not experts in this. Wally Poston or Murray Stein or others here can answer those questions. All we are

interested in is keeping the nutrients out of the lake.

MR. HOLMER: I share your concern for the nutrients.

MR. CARBINE: So that little statement there was just a little pipe dream that we put in, pump it out on the land.

(Laughter.)

MR. STEIN: Are there any other comments or questions?

MR. KLASSEN: Mr. Chairman, I have one more.

MR. STEIN: Yes, Mr. Klassen.

MR. KLASSEN: I think in the report of the Federal Water Pollution Control Administration there was reference made, if I recall, to the pesticide content of the bottom sludges. Do you have methods for determining the pesticide content of the waters themselves and a so-called parameter or a limit in the water itself, discounting the sludges?

We were interested in this because we obviously not only on Lake Michigan but on our other streams are interested in this point.

I would appreciate--

MR. CARBINE: We are very much interested in it also and we have taken thousands of water samples and thousands of bottom samples from all over the lakes. We haven't a good technique yet for working them up. I don't believe anyone has.

We had a seminar on this subject just a few weeks ago and we had experts in from all over, and I don't believe anyone can examine or analyze pesticides contained in the mud, bottom mud.

MR. KLASSEN: Thank you.

Would you like a little bit on the alewife or not?

MR. STEIN: I think we had better do something on the alewives, although we do have--I have got to make one comment, and maybe off the record.

(Off the record.)

MR. CARBINE: The interesting thing about the alewife is that it occupies every niche.

MR. STEIN: Yes.

MR. CARBINE: And it is transferring the nutrients around the lake.

MR. STEIN: Yes.

MR. CARBINE: But before I introduce the next speaker, I would just like to make one remark.

Mr. Clevenger yesterday in his remarks alluded to the task force set up by the Department of Interior. He kind of passed it off in a facetious way, indicating that the task force missed the boat entirely because they didn't figure out a way of removing the dead alewives from the beach.

Well, I would like you all to know that the Department of Interior task force was composed of administrators and scientists, the best in the Department of Interior. They considered the beach cleanup thoroughly, but they figured that what was basically needed here was not a treatment but a cure, and the task force report goes into some detail on a research program that will get at the basic facts of this alewife death and maybe we can prevent it by doing something.

We happen to know a little about handling fish populations. We have been in the sea lamprey control business for a good many years, and we know a little about controlling fish populations.

So we urge everyone to get a copy of this task force report that was put out by Interior and study it and you will see that the basic premise laid down by the committee was sound.

MR. STEIN: Before we have Mr. Premetz, I think Mr. Klassen has another question.

MR. KLASSEN: I have one more question to clarify a little confusion in my own mind here.

You have referred to Lake Michigan as approaching the lethal level.

Number one, I would like--I highly respect your opinion--what do you consider is the lethal level?

And secondly, if analytical determinations are so difficult, how do you know analytically you are approaching that lethal level?

MR. CARBINE: Analytical work on bottom muds and water is extremely difficult, but we have our techniques worked out pretty well for fish and the reference was made concerning the fish themselves.

I do not know exactly what the lethal level is. We should know in a short time, probably, we and some of our colleagues.

I would just as soon let it go at that, I don't know what the lethal level is.

MR. KLASSEN: You made the statement Lake Michigan is approaching the lethal level.

MR. CARBINE: Well, pretty much.

MR. KLASSEN: What did you have in mind, if you don't know what the lethal level is?

MR. CARBINE: We only have a few studies upon which to base this lethal level and this is all we are going on. At this time we would be rather foolish to come out and say that 8 parts per million or 14 or 16 is it.

MR. KLASSEN: But you did say Lake Michigan is approaching the lethal level?

MR. CARBINE: Yes.

MR. KLASSEN: And inasmuch as--

MR. CARBINE: Maybe that was a little too strong. It is getting very high.

MR. KLASSEN: All right. I was interested in this because it is part of my responsibility to sample Lake Michigan and know when we are approaching some of these levels, and this is my reason for asking, so that we will know whether we are approaching the lethal level, and to do this, of course, we have to know what the lethal level is. This is my question.

MR. CARBINE: Yes. All we can go on is what is allowed in meat and other things, and using a few of these for background, that is why we came up with that statement.

MR. KLASSEN: Thank you.

MR. CARBINE: Mr. Ernest D. Premetz.

MR. STEIN: While he is coming up, Mr. Klassen, I would like to make one remark, and that is that we do have a problem with these pesticides and trace elements in determining a lethal level and talking about a

lethal level in advance. The problem is, the worst way we can find out what the lethal level is is finding out we have got some dead fish. Even in the cases where we have had dead fish, I have not been able to get the scientists to tell me precisely what the lethal level is, although we did know one thing it was doing, it was killing fish.

I remember in a case that we had down in the Southwest, they were fooling around with this lethal level until I finally got the biologist to put the fish in the tank and said, "Put some of the stuff in and see if it kills them," so they did. And then I said, "Why don't you start diluting it," and they diluted it 5, 10, 15 times and it still killed the fish. And I said, "Well, I guess that stuff is poisonous, we had better ask the fellow upstream to stop putting it in the stream."

But as far as I know, they published a lot of papers and they never did know what the lethal level is yet.

MR. KLASSEN: You are not going to

get me into this because at the previous conference I was accused of being a barber shop biologist and I am the first one to agree with that.

MR. STEIN: I think we can finish. And this is our discussion, as far as I can see, on alewives for the day or for tne conference.

ERNEST D. PREMETZ

STATEMENT BY ERNEST D. PREMETZ
DEPUTY REGIONAL DIRECTOR
GREAT LAKES-CENTRAL REGION
BUREAU OF COMMERCIAL FISHERIES

MR. PREMETZ: Mr. Chairman, honorable conferees, and referees.

My name is Ernest Premetz. I am Deputy Director for the Great Lakes-Central Region, Bureau of Commercial Fisheries.

I don't think I have to tell you about the alewife problem. You all lived with it here in Chicago this past summer. This was a massive mortality, actually the largest ever seen in any freshwater body.

There have been estimates of several hundred billion fish dying; some have said there were several billion fish died. Honestly we can't tell you. We did sample beaches. We came up with figures of several hundred million. But the fishermen themselves out in the open lake reported getting into areas where the bottom was

loaded with goop, that is dead alewives, in some cases as much as 6 feet off the bottom. So your guess is as good as mine as to how many died out there.

Now, another unusual thing that happened. This die-off started in midwinter, and these fish started dying not only in Lake Michigan at that time, but also in Lake Erie, Lake Ontario and Lake Huron.

There have been many theories advanced as to the reason for this massive die-off in Lake Michigan, including such things as disease, starvation, temperature change, lack of oxygen, what-have-you. However, our scientists, on the basis of studies which are being concluded at the present time, feel that temperatures provide the logical explanation and that the Great Lakes alewife was actually suffering from what is known as thyroid exhaustion. The thyroid in the fish is related to growth, osmotic regulation, temperature tolerance, among other things.

One of the problems the alewife

has in the Great Lakes is it lacks iodine in its environment. We have the same problems. In fact I suffer from a thyroid deficiency; I take four grains of thyroid a day to keep my thyroid action up.

Well, the alewife during the winter, because of the extremely cold waters on the bottom, was forced to draw on its thyroid reserve. Some of these fish exhausted their reserves and died. Others reduced these levels. Then as they moved inshore for spawning, they again were forced to draw on their thyroid reserves for the spawning process.

Then they ran into another little thing, there was a sharp temperature gradient from the offshore waters to the inshore waters, which meant they had to draw on more of this thyroid reserve. They didn't have this, so they died.

Of course another unusual thing this year too is normally you would expect that the die-off would consist entirely of three- and four-year olds, that is fish

that had lived out their lifespan. About 25 percent of the fish that we sampled on the beaches were one-year olds. We surmised that the two-year olds may have been the ones that are on the bottom because these fish did not get into shore. As I mentioned before, there were massive quantities on the bottom, quantities of this goop that were picked up by trawlers and other commercial fishermen.

I am not going to go into a lot of detail about the history of the alewife. Suffice to say that it was first introduced into Lake Ontario in the 1870's. Most of our people feel it was probably an accidental introduction at the time that man started monkeying with the environment and dumping shad in Lake Ontario. They accidentally dumped alewives there. It took a long time for these fish to get from Lake Ontario into Lake Erie, subsequently into Lake Huron and then into Lake Michigan. Actually the Welling Canal was an effective barrier just as it was with the sea lamprey. It

took the sea lamprey 100 years to get through the Welling Canal before it got into Lake Erie and out into the upper lakes.

Some people have said, "Well, maybe we have got some problems with the St. Lawrence Seaway of reintroduction." We haven't this problem because this is actually an effective barrier. All of these locks and dams are an effective barrier to the alewife.

This fish dominates the population in Lake Michigan. We have estimates that in excess of 90 percent of the fish flesh in Lake Michigan consists of alewives. In Lake Ontario we have a situation where we might say it is like Ivory soap, 99 and 44 one-hundredths percent pure alewife. We can look for the same thing in Lake Michigan in time.

What has this fish done in its dominance of the lake? It is an extremely effective feeder. It out competes everything else. In the process of competition it has eliminated certain species of chub, other species are on the way down. Lake herring

have declined drastically, the smelt populations are feeling pressures, many, many other species, such as the emerald shiner, the yellow perch are also being subjected to increasing competition or are actually disappearing. So what we are getting to is a lake that is far less productive than it might be.

For example, Lake Ontario is a case in point. This is a lake that for all intents and purposes, because of the nutrients available and all of these things in the lake, should be highly productive, and yet it is not, simply because it is dominated by the alewife.

So what is the answer? How do we get rid of the alewife? I can't tell you that right now but I think we had better start worrying about it. There have been some indications that perhaps we should plant more predators. Fine, they eat a lot of alewives, your coho salmon, your lake trout, eat a lot of these. They don't like them, but they eat them because there is nothing else available. They spit them out and then they finally get hungry enough to eat them.

But the problem is here we are expending millions and millions of dollars to introduce choice sport species of fish in the lake with no assurance that these fish are going to be able to survive in the lake if something happens to these alewife populations, which are subject to extreme ups and downs. It is an extremely unstable population.

Now, I know most of you want to get away from here, you don't want to ruin your day by talking about alewives for the rest of the day. Mr. Carbine has mentioned the task force report. This can be made a part of the record. I think this very, very clearly outlines the whole problem.

And the only point I want to make is, for God sakes, let's not start quibbling about numbers and pointing fingers at the guy down the stream, things of this sort. Let's all get our shoulders to the wheel and do something about it because soon, fellows, it is going to be too late with all of this.

This whole resource is in jeopardy.

We have seen it happen in Lake Erie. It is going to happen in Lake Michigan if we don't do something about it. We fortunately have a little time yet.

And in doing these things, let's not think entirely in terms of some sort of stop-gap measures. Take the best knowledge we have now to try to effect at least a reasonable cure to our problems. This applies to alewives too. Sure we should worry about dead alewives on the beaches, but we should also worry about the fact that this is a sign of something that is happening in the lake and something we should be concerned about and something we should be doing something about.

We don't have all the answers yet. We are working very hard on a very limited budget to try to get these answers. I think it is going to take not only our small organization but all the organizations that are concerned in the Great Lakes Basin, putting their shoulders to the wheel, doing research and coming up with some answers.

Let's not worry about the numbers,

fellows. Let's worry about doing something about the problems that face us now, use our best judgment. And believe me, a lot of what we say here is based on judgment, based on past experience. And if you can't rely on the judgment of scientists that have spent their lifetimes researching in the Great Lakes area, I don't know who you can depend on.

That is all I have to say.

(The paper submitted by Mr. Ernest Premetz is as follows:)

The Great Lakes Alewife Problem

The recent massive mortality of alewife in Lake Michigan has graphically focused attention on the problems generated by its invasion of the Great Lakes system. The alewife is showing promise of outdoing the notorious sea lamprey in respect to upsetting the ecological balance of the Great Lakes and is, in addition, creating extremely serious and costly nuisance problems--the littering of beaches and harbors, and the clogging of water intakes.

This year's alewife die-off was tremendous--estimated at several hundred millions of pounds. It created a horrendous cleanup problem on the beaches, particularly in the southern Lake Michigan area. The die-off of alewife in Lake Michigan actually started in midwinter. Similar winter die-offs were reported in Lakes Erie and Huron. Many theories have been advanced as to the reason for this year's massive alewife mortality in Lake Michigan, including disease, starvation, temperature change, and lack of oxygen. Scientists of the Department's Bureau of Commercial Fisheries feel that temperature may provide the most logical explanation, or at least, it may play a key role as the factor which triggered the mortality. It has been well established that the Great Lakes alewife exhibits thyroid exhaustion. Although all the functions of the thyroid are not understood for fish, it has been suggested that it may be related to growth, osmotic regulation, and temperature tolerance among other things. We do know that alewives are subjected to sharp

temperature gradients as they move shoreward in the spring and early summer. Thyroid exhaustion also provides a possible theory for the midwinter mortality since it has been suggested that thyroid hormone favors resistance to low temperature.

In view of this year's massive mortality, scientists in the Department's Bureau of Commercial Fisheries believe that a reduction in the number of alewives is probable, but that substantial die-offs will continue in coming years, as has been the case in Lake Ontario where alewife die-offs have been occurring since the 1880's.

The alewife has been known to occur in Lake Ontario since the late 1800's. They may have entered Lake Ontario via the St. Lawrence River from their native habitat along the Atlantic Coast or could have been introduced accidentally when shipments of shad were released in the lake in the early 1870's. The alewife was very abundant in Lake Ontario by 1890 and continues to be the most abundant fish of the lake today.

Niagara Falls would have blocked movement of the alewife into the upper Great Lakes but they were able to migrate through the Welland Canal which connects Lake Erie and Lake Ontario. They were first recorded in Lake Erie in 1931 and became abundant there by 1942. From Lake Erie the alewife had free passage into the upper Great Lakes. It was first recorded in Lake Huron in 1933, in Lake Michigan in 1949, and in Lake Superior in 1954.

Although the alewife became very abundant in Lake Erie, it did not dominate the fish population and become the most abundant species of the lake as it did in Lake Ontario. Conditions in Lakes Huron and Michigan were well suited for the alewife, however, and it increased rapidly until it became the most abundant species of these lakes. It reached its maximum abundance in Lake Huron about 1961 and appeared to be approaching its greatest abundance in Lake Michigan during 1966-67. The alewife has spread throughout Lake Superior and its numbers

have increased steadily in recent years, but it has not yet reached great abundance there.

The alewife does not grow as large in the Great Lakes as it does in the ocean. In Lakes Michigan and Huron most adult alewives are 5 to 7 inches long and very few are longer than 8 inches. They become adults when they are 2 years old, most of them die during the summer when they are 3 years old, and very few live beyond the 4th year after they hatch.

The alewife occurs in dense schools and is extremely abundant in various sections of the lakes during different periods of the year. Adults are concentrated in the deepest waters in midwinter, they move toward shore along the bottom through the intermediate depths during late winter and early spring, then again become concentrated in the shallow areas near shore and in rivers in the summer where they spawn. After spawning they move into intermediate depths in the fall. The young hatch during the summer and spend most of their first 2 years after hatching at

middepths in the lake.

The extreme abundance of alewives in lakes where they have become the dominant species has been associated with the near disappearance or sharp decline of all of the species that were previously very abundant. The chubs which occupied the deeper areas of the lakes and the smelt that lived in the intermediate and shallow areas are declining sharply. In the shallower areas the lake herring and emerald shiner that were extremely abundant have all but disappeared, and the yellow perch which lives near shore has declined during periods of peak alewife abundance. Thus, the alewife has taken the place of the many previously abundant species in those Great Lakes where it has become the dominant species.

Since the alewife occupies only part of a lake during any season and has eliminated the many species that lived in all segments of the lake throughout the entire year, it appears that the alewife has made the lakes less productive. The

striking example of this is found in Lake Ontario which is the least productive of the Great Lakes and where the alewife has been the dominant species for many years. From the standpoint of water quality Lake Ontario should be very productive and is, in terms of invertebrate fish food organisms, but very few fish occupy the vast open waters of the lake.

The alewife is having an effect on industries and municipalities as well as on the endemic species of the Great Lakes system. One steel plant, and there are several on the southern shore of Lake Michigan, estimated a loss of approximately half a million dollars per day for about 10 days in April 1966 when cleaning screens on the cooling water system were unable to cope with alewife entering the intakes. The screening system was inadequate even though it removed 60 tons of fish per day. Electric power generating plants in Illinois were seriously affected at about the same time when it became necessary to alternately shut down half the generators while cooling water

screens on the other half were cleaned.

Chicago's new central district water filtration plant, the second largest of its kind in the world, operated at reduced capacity in April 1965 when alewife caused breakdowns to 20 percent of the cleaning screens which were handling 10 tons of fish per hour. This water supply to some 2.7 million people was success fully protected in 1966 by an alewife diversion system designed by gear specialists of the Department's Bureau of Commercial Fisheries.

A solution to the problems caused by the dominance of the alewife in the Great Lakes has not been attempted. When the alewife has become the most productive species, fisheries have declined, and communities around the lakes have learned to live with and accept the annual spring die-off. Since no attempts have been made to restore a lake dominated by the alewife to its previous productivity, there are no known solutions.

The objective of a lasting solution to the alewife problem would be to restore the ecological balance in the lakes by

reestablishing a multiple species complex. Short-term solutions of intensive fishing, or intensive stocking of predator species, or both, will not restore the ecological balance but may, in fact, cause greater instability because of cyclic interactions between the fishery or the predator and the single target species.

The only lasting solution can be obtained by understanding the ecological characteristics of the previous multiple species complex and learning how the alewife was able to dominate the lake by eliminating other abundant prey species. With such knowledge, it should be possible to manipulate the fisheries, the introduction of predators, and the introduction of previous or new prey species in a way that will restore ecological balance and full fishery productivity of the lakes.

Some of the States have advocated that the Great Lakes be managed for sport fisheries, with commercial fisheries relegated to the secondary role of harvesting fishes

surplus to the projected demand of sportsmen. Bureau of Commercial Fisheries scientists feel this is a serious mistake. A single purpose and highly selective fishery is bad from the biological standpoint, and it makes little difference if the fishing is done by commercial fishermen, sport fishermen, or the sea lamprey. Balanced fish stocks with many interacting species are the most stable and productive fish stocks. The easiest way to maintain balanced stocks is to have diverse fisheries. Both sport and commercial fisheries tend to be highly selective for only a few preferred species and both can do themselves in if not controlled. Both types of fishery can be controlled to make certain that a stock is not overfished, but where you have an intensive sport fishery alone, it cannot be regulated to keep the stocks in balance. Thus it is essential to have a balanced and well-regulated commercial fishery that can take species that would move in and take over if preferred species were either fished too heavily or not heavily enough. In small lakes this type of population

control is often accomplished by poisoning and restocking or by special contract fishing, but the Great Lakes are so large that poisoning is impossible and contract fishing requirements would be so large that no one operator could meet the need nor could they be called on just when a special need developed--the capability would have to be there and working all the time.

Although the alewife problem demands our immediate attention, scientists of the Department's Bureau of Commercial Fisheries point out that Lake Michigan may be faced with an even greater and more serious problem from eutrophication in the near future. The Bureau hopes that its early warning with respect to Lake Michigan pollution is not ignored as it was some 15 years ago when Bureau scientists warned of impending disaster in Lake Erie. Scientists tell us that the flushing rate of Lake Michigan is much less than Lake Erie which has already become badly polluted. This means that once the enrichment of Lake Michigan starts, it will progress at a far more rapid rate than it did in Lake Erie,

and if Lake Michigan does, in fact, become over-enriched (polluted from the ecological standpoint), many generations will be required for it to recover. The seriousness of the problem in Lake Michigan is accentuated by the fact that Lake Erie is flushed by relatively clean Lake Huron water that runs in one end of the lake and out the other, whereas Lake Michigan is flushed less efficiently by rich (often polluted) water that enters from tributaries which drain mostly urban, industrial, and farm areas on the east shore and northern section of the lake. Also, Lake Michigan appears to have built up a firm crust-like layer at least in the southern area which in effect seals off the bottom and may keep nutrients in constant circulation once they have entered the lake. Bureau scientists have evidence to show that Lake Michigan is already on the borderline of being classed as an eutrophic lake, and that enrichment has started. All of this means that the enrichment that has started in Lake Michigan may be near the brink of the point of sharp increase (as occurred in Lake

Erie a short time ago), and that once the increase has started, it may progress at such a rapid rate that any corrective measures may be too late and ineffective. The time for action is now--the fuse is already lit, and if it is not put out, the explosive enrichment may take place in the next 10 to 15 years. The frightening thing is that what could take place in this short period would require 100 years or more to correct.

Recognizing the seriousness of the resource and sociological problems occasioned by the Great Lakes alewife invasion, Secretary of the Interior Steward L. Udall recently named a Federal task force, chaired by Dr. Stanley A. Cain, Assistant Secretary of the Interior for Fish and Wildlife and Parks, to consider corrective measures. Other task force members are: Frank C. DiLuzio, Former Assistant Secretary for Water Pollution Control; Former Commissioner James M. Quigley, Water Pollution Control Administration; Director H. E. Crowther, Bureau of Commercial Fisheries; Director John S. Gottschalk, Bureau of Sport Fisheries and Wildlife;

and Dr. Milner B. Schaefer, Science Advisor to Secretary Udall. The task force will carefully evaluate all suggestions for aleviating the alewife problem, including Federal-State co-operation in cleanup campaigns, harvesting of alewives for manufacture of fish meal, pet food and perhaps human food products, stocking of Lake Michigan with alewife predators such as lake trout and coho salmon, and improved methods of collecting dead alewives before they reach the beaches. Although the Department of the Interior feels that the only lasting solution to the alewife problem is the restoration of ecological balance in the Great Lakes, it recognizes that this long term research effort must be complemented with interim control measures to alleviate problems occasioned by the large annual die-offs which are characteristic of this species. The Department alewife task force will shortly propose both immediate and long range measures to bring the alewife invader under effective control.

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ERNEST D. PREMETZ

MR. KLASSEN: Mr. Chairman, could I ask a question of the speaker?

MR. STEIN: Surely.

MR. KLASSEN: Since I raised this number thing, I want to get down to something a little more practical.

One, based on your studies with, I understand, underwater television, nets, and what other devices you have, do you anticipate--I am going to ask you two questions--do you anticipate that we will have a greater, the same or a lesser problem with alewives deaths in Lake Michigan this coming early summer than we had last year?

And, two, is the Federal Government devising a program for the collection and disposal of dead fish?

MR. PREMETZ: O. K., I will answer both of them.

The first question, do we have a fix on the magnitude of the die-off that we might expect. Well, from our sampling this fall, and we are continuing with the sample, we found that the die-off last year

reduced the adult populations substantially, so these fish aren't there to die. That is the 3-year-olds which might have lived on to age 4.

The 2-year-olds, we find that this was an extremely poor year class. I mentioned this fluctuation. So these will be 3-year-olds now. These, too, are not in tremendous quantity. That is relatively speaking. There are still a lot of fish out there.

But one thing that has disturbed us is that the young of the year, that is the very recent hatch, is about the highest on record. In other words, because competition has been reduced from adults, this has given the young a chance to--in other words, more eggs to survive and more young to be spawned and there is every indication that more will survive to the adult stage. So look out in 1970.

Now, the second one, what is being done. Mr. Carbine mentioned the Interior task force report, which went into the program that would be needed, restricted itself

primarily to research functions that might be undertaken by an agency such as Interior, which is primarily a research agency. It did come out and state that it was the feeling of the task force that the cleanup of beaches was not something the Federal Government could undertake because this would be a tremendous drain on the U. S. Treasury. We have these die-offs in every single one of the lakes; we have it in every river; we have it along the coastline. You have heard of the red tide out in Florida where massive quantities of fish die. I must say that in Lake Ontario people have lived with die-offs since 1880.

So certainly, I am not saying that something must not be done. We have got to mobilize forces to do something about this. I don't know where the funding is coming from to do the job. I think Mr. Clevenger mentioned that the Great Lakes Basin Commission is at the present time trying to develop a program, a cohesive program, to deal with this particular problem. We are working very closely with Mr. Clevenger and his people

as well in trying to lend our expertise to this problem.

It is not an easy one, though, and I think the point that has to be made is that if we think we are suddenly going to lick this problem immediately overnight, we have got another think coming. These dead alewives are going to be with us. Hopefully through concerted action of all of the municipalities, the States, perhaps even the Federal Government, the problem can be reduced somewhat.

But as Mr. Carbine pointed out to you, let's start looking for a cure rather than a continuing treatment. And this is the thing that concerns me. If they have been worried about alewives and cleaning up alewives in Lake Ontario since 1880, you could be faced with the same thing here in the City of Chicago for that period of time.

MR. CARBINE: Ernie, I think I can answer his question more direct.

Mr. Clevenger's task force will start working on its report next Monday. The Great Lakes Basin Commission meets on February 15

and they will go over this report, decide what to do, but they are definitely going to call a conference for Chicago the last of February.

Is that it, Mr. Mitchell?

So this coordinated effort of everybody around the lake will get together in late February to decide how they are going to clean up the beaches, and so forth.

MR. KLASSEN: Thank you.

MR. STEIN: Are there any further questions or comments?

Before we adjourn, and this I want to say to the conferees, I don't want to preclude the scope of the conference in dealing with pollution problems such as the cleanup of beaches from alewives unless you think this is a proper subject. Or do you want us to make a recommendation? This is something that the State conferees should consider.

With that we will stand recessed until 9:30 tomorrow morning.

(Whereupon, at 6:35 p.m., an adjournment was taken.)

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