STATEMENT ON WATER POLLUTION
IN THE
LAKE ONTARIO BASIN

July 1966

STATEMENT
ON
WATER POLLUTION IN THE LAKE ONTARIO BASIN

PREPARED FOR
THE NATURAL RESOURCES AND POWER SUBCOMMITTEE
OF THE HOUSE COMMITTEE ON GOVERNMENT OPERATIONS

by

U. S. DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration
Great Lakes-Illinois River Basins Project
Great Lakes Region

Chicago, Illinois

July 1966

ENVIRONMENTAL PROTECTION AGENCY

STATEMENT ON WATER POLLUTION

IN THE

LAKE ONTARIO BASIN

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Change

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Page

5-4 The last paragraph should read:

The 9 installations listed in Table 5-3 discharge about 753,000 gallons of waste per day to surface waters. Five of these installations have secondary treatment facilities, treating approximately 310,000 gallons per day. A total of 50,000 gallons per day discharge directly to ground disposal systems from the remaining 51 installations. The Veterans Administration Hospital, Canandaigua, will construct secondary treatment facilities within a year, and Camp Drum has secondary treatment facilities budgeted for 1969. These are two of the larger installations.

Table

5-3 Delete Air Force Plant #38 from table. (Plant never opened; used for storage purposes only.)

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Page

5-1 4th paragraph, 3rd sentence: "The City of Syracuse . . ." should read "Onondaga County . . .". In 4th sentence: 325,000 PE should read 460,000 PE.

Table

5-2 Dupont, E. I., Niagara Falls: Under LBS BOD/DAY, 13,400 should read 2,700; under POPULATION EQUIVALENT, 80,400 should read 13,400.

Hooker Chemical, Niagara Falls: Under LBS BOD/DAY, 22,800 should read 3,800; under POPULATION EQUIVALENT, 136,800 should read 22,800.

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SUMMARY

General

Problems related to water pollution have been identified in Lake Ontario and most of its tributary streams. Some of these waters, particularly Lake Ontario, are experiencing the effects of over-fertilization which promotes massive growths of algae. These growths, sometimes called "blooms", seriously impair many important water uses and cause objectionable nuisance conditions that often exceed the tolerance levels of even the most insensitive persons.

Other waters are seriously degraded, adversely affecting desirable beneficial uses. Water supplies, swimming, boating, fishing, and esthetic enjoyment are among the uses impaired by this degradation. Except for certain streams in the hinterland areas of the watershed where man's activities are minimal, there is evidence of pollution effects practically everywhere in the water environment. While some of the effects are minor impairments today, they are the harbingers of more serious conditions that are sure to develop as a result of population and economic growth in the years ahead if effective measures are not taken at the right time in the necessary places.

Sources of Pollution

Municipal waste treatment plants in the Program Area serve an estimated present population of 1,544,000. These plants receive additional waste loads from industries, a total population equivalent (PE) of about 2,350,000 (in terms of oxygen consuming capacity). Of the combined untreated waste PE of 3,894,000 received by the plants, an estimated PE of 2,299,000 is discharged to the receiving waters. This represents an overall average removal efficiency of about 41 per cent, which is considerably less than removals of 90 per cent or more attainable with secondary plants.

Approximately 300 industries discharge varying amounts of oxygen demanding wastes directly to receiving waters. In most cases little or no treatment is provided. The biochemical oxygen demand (BOD) of the wastes discharged by 52 of these industries is estimated to be 423,000 pounds per day, which is about 96 per cent of the BOD from the 300 industries.

Other significant waste sources are overflows from combined sewer systems, runoff from urban and rural areas, and wastes from commercial and private vessels.

In addition to the organic oxygen demanding wastes other problem contaminants discharged to the environment include the algae nutrients, phosphorus and nitrogen compounds, phenols, toxic materials, oil and grease, acids, alkalies, and bacteria.

Major Problems

Certain water bodies and sectors are experiencing problems of unusual magnitude and complexity. The technical measures and remedial actions necessary to achieve satisfactory quality will involve major improvements requiring

large expenditures. The most severe problem conditions are summarized in the paragraphs following.

Lake Ontario

Present nutrient levels now support prolific algal growths which cause severe impairment to water supplies and obnoxious conditions in swimming and shoreline residential areas. The remedy that appears most feasible at this time is reducing the input of phosphorus to the Lake.

Eastern Lake Erie - Niagara River

Gross industrial pollution in the Buffalo River and municipal and industrial pollution along the United States shoreline of the Niagara River are described in the Federal Technical Report prepared for the Federal Enforcement Conference on Lake Erie. The unanimous recommendations of the conferees specify improved treatment and other measures to correct the situation. These recommendations were subsequently adopted by the Secretary of Health, Education and Welfare.

Rochester Area

The discharge of large volumes of poorly treated wastes into the Rochester Embayment constitutes a continuing hazard to swimming and other recreational use of the waters. Contravention of the present State classification is an established fact.

The lower three miles of the Genesee River are depleted of oxygen during the summer months, primarily due to the organic load in the effluent from Eastman Kodak Company's waste treatment plant. This industry has conducted extensive research to determine a feasible method of providing additional treatment. These studies are now completed and agreement has been made with the State of New York to have secondary facilities in operation by 1970. Contributing to the problem is the organic load discharged during periods of overflow by the combined sewers of the City of Rochester.

Syracuse Area

Onondaga Lake, situated on the north side of Syracuse, receives the effluent from municipal treatment plants serving the metropolitan Syracuse area. On the west side the Allied Chemical Company's Solvay Division discharges a variety of wastes to the Lake. This Lake is considered to be the most grossly polluted body of water in the Program Area. Overflows from combined sewers of the City of Syracuse are known to contribute significantly to the problems. Huge volumes of sludge, both mineral and organic, have been found.

Recent actions by officials of Onondaga County, the City of Syracuse, and Syracuse area industries are very encouraging. Substantial support by all levels of government is imperative.

Oneida Lake

Probably one of the most heavily fertilized water bodies in the eastern United States, Oneida Lake is an important resource that merits a substantial effort to eliminate problems now experienced. Control of nutrients and adequate waste treatment are paramount needs.

Black River

Noted for its paper mills, the lower 80 miles receives wastes with a total PE of about 640,000. Conditions below outfalls of nine mills are characterized as grossly polluted.

Lake Ontario Program

A program is being developed in cooperation with the New York State Department of Health, other State agencies, and local governments, which will set forth the control measures and improvement that must be provided to achieve satisfactory water quality. Field investigations and laboratory analyses are completed. Engineering and economic analyses now in progress will provide the technical basis for framing the programs. Completion of the comprehensive water pollution control program is expected early in 1967.

CHAPTER 1

INTRODUCTION

This Statement reports the findings of a water quality study of the Lake Ontario Basin made during the past two years by the Lake Ontario Program Office, located in Rochester, New York. The study has a primary mission of developing a comprehensive water pollution control program for the Lake Ontario Basin, one of several being developed by the Federal Water Pollution Control Administration for the Nation's major river basins.

The Lake Ontario Program Office is part of the Great Lakes-Illinois River Basins (GLIRB) Project, headquartered in Chicago.

The Project has the following general objectives:

1. The determination of the causes of water pollution and the effects of such pollution on both the quality and the beneficial uses of our water resources.

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

3. The determination of water pollution control measures necessary to achieve the desired water quality objectives, including a timetable for their accomplishment.

4. Implementation of the comprehensive programs which embody the control measures and surveillance activities essential to achieving our common goal of clean, clear water.

The geographic area covered by this report includes Lake Ontario, its tributary waters and related land area, and the United States portion of the St. Lawrence River watershed to the Canadian Border.

Field survey and laboratory work are essentially completed, and evaluation of the data is now underway. Based on study findings, a series of Comprehensive Water Pollution Control Programs covering the St. Lawrence, Black, Oswego, Genesee and Lower Niagara Rivers, Lake Ontario minor tributaries, and Lake Ontario itself will be developed for implementation by those agencies having responsibility for water pollution control.

As directed by the Federal Water Pollution Control Act, the Program is being conducted in cooperation with other Federal agencies, State agencies, and local interests - especially, in this case, with the State of New York. Valuable counsel and advice have been received from responsible people in a number of private and public agencies. Many County groups and boards, such as health and planning agencies, have been instrumental in providing local information. Private agencies and universities have provided information and reports useful to this Program. The Canadian Government, in carrying out its own studies, has also cooperated with this office.

CHAPTER 2

RECOMMENDED ACTIONS

Introduction

Although engineering and economic analyses for developing the final program are still in progress, work has advanced to the point that many of the improvement measures necessary to achieve program objectives have been determined. Some of these measures apply present technology to problems needing immediate correction and are based on experience gained in solving similar problems elsewhere. They will be reviewed as the studies progress to determine whether any modifications should be made prior to inclusion in the final program.

Long-range needs are currently being determined using more detailed and sophisticated analyses. These include the need for storage for stream flow regulation, advanced waste treatment, and related alternatives.

Recommendations

1. All municipal waste treatment facilities should be designed to provide secondary (biological) waste treatment to achieve an overall reduction in untreated BOD (5-day Biochemical Oxygen Demand) of 90 per cent or higher on a continuous basis.

2. Continuous disinfection should be provided for all municipal waste treatment plant effluents.

3. Maximization of phosphate removal should be an immediate objective in the design of new secondary waste treatment facilities and in the operation of existing facilities.

4. All separately discharging industrial wastes should receive the equivalent of secondary treatment, as described above. Where practicable, industrial wastes should be discharged to municipal sewerage systems so as to receive final treatment at properly designed and operated municipal treatment plants.

5. Master plans for future waste collection and treatment facilities should be developed for the rapidly urbanizing metropolitan areas as quickly as possible. Such plans should provide, among other things, for maximum use of integrated facilities which will permit eventual elimination of the conglomeration of small, inefficient facilities surrounded by residential and commercial development. Metropolitan or county-wide authorities are strongly recommended.

6. Combined sewers should be strictly prohibited in all newly developed urban areas and should be separated in coordination with urban renewal projects. Existing combined sewer systems, particularly in Buffalo, Neagara Falls, Rochester and Syracuse, should be patrolled on a regular schedule. Overflow regulating devices should be adjusted to convey the maximum practicable amount of combined flow to treatment facilities.

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7. The New York State Department of Health, or designated pollution control unit under its jurisdiction, should conduct waste treatment plant inspections at least once a year for facilities serving less than 10,000 people (or equivalent plant) and at least twice annually for larger plants.

8. Monthly reports covering the operation of municipal waste treatment plants should be submitted to the New York State Department of Health for review, evaluation, and appropriate action.

9. The State and County water quality monitoring programs should be intensified and use of automated equipment is strongly recommended in key location. The monitoring program should be supplemented by monthly reports covering the quantity and quality of all significant municipal and industrial wastes discharged in the Program area. Data on waste discharges should be kept in open files, readily available to all agencies and individuals who have legitimate need for such information.

10. Adequate monitoring of swimming and other recreational waters is urgently needed. A lack of background data on heavily used beach areas seriously hampers making conclusive judgments on the health hazards. Epidemiological studies should be instituted and correlated with other surveys.

CHAPTER 3

DESCRIPTION OF AREA

Geography

The watershed tributary to Lake Ontario contains a total drainage area of approximately 35,000 square miles. The Lake Ontario Program area contains nearly 17,700 square miles of land and includes the Lake proper, the United States portion of the watershed tributary to the Lake, and the United States portion of the St. Lawrence R iver watershed. Except for a small part of the Genesee River Basin, the entire program area is located in New York State.

Hydrology

Lake Ontario is approximately 190 miles long and has a mean width of 53 miles. The average depth is 300 feet. There are four major rivers and a large number of minor streams draining into Lake Ontario as shown in Figure 3-1. The four major rivers are the Niagara, Genesee, Oswego and the Black. The drainage areas for the major rivers are shown in Table 3-1.

TABLE 3-1

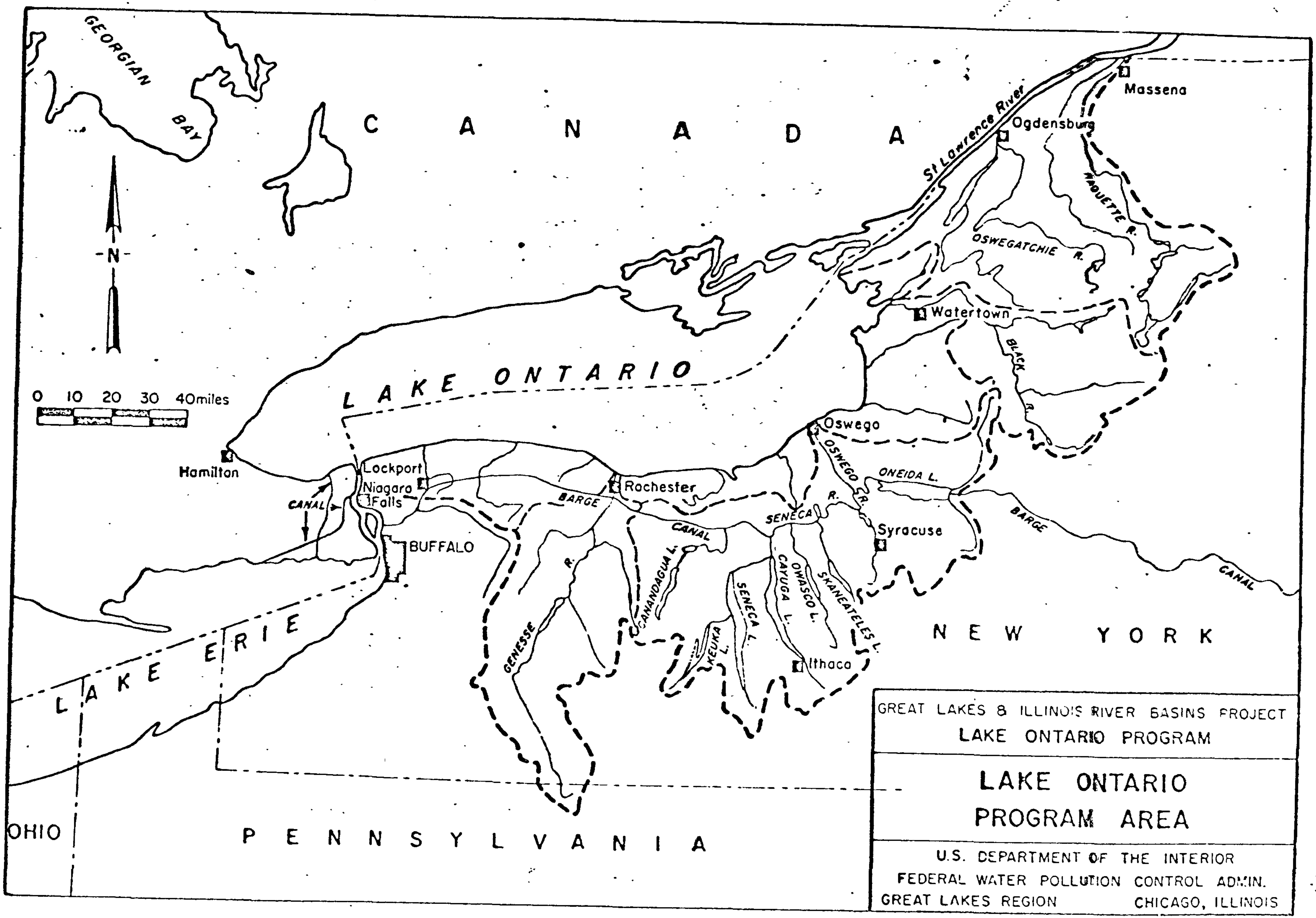
Drainage Areas - Major Tributaries of Lake Ontario

River	Length of River(mi)	Drainage Area (sq.mi.)	Average Flow CFS
Niagara	37	1688	203,000
Genesee	160	2479	2,739
Oswego	24	5000	6,320
Black	112	1916	3,872

The Niagara River, containing the famous Niagara Falls, is the natural waterway connecting Lakes Erie and Ontario. The river is the International Boundary between the United States and Canada.

The Genesee River originates in northern Pennsylvania and flows north some 160 miles into Lake Ontario at Rochester, New York. The drainage basin averages about 27 miles in width. The river flows through narrow passage ways and is noted for its scenic gorges.

The Oswego River appears to be an outgrowth of the natural formation of the Finger Lakes and Seneca River. A major tributary, the Seneca River, drains the Finger Lakes and enters the Oswego River several miles north of Syracuse. The Finger Lakes consist of Lake Owasco, Canandaigua, Keuka, Seneca, Cayuga, Skaneateles and Otisco. The Oswego River continues north and enters the lake at Oswego. The main axis of the drainage basin takes a northeasterly direction. The Oswego drainage basin is about 85 miles long and 70 miles wide.


GREAT LAKES & ILLINOIS RIVER BASINS PROJECT
LAKE ONTARIO PROGRAM
LAKE ONTARIO
PROGRAM AREA
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
GREAT LAKES REGION
CHICAGO, ILLINOIS
GEORGIAN BAY
CANADA
N
0 10 20 30 40miles
LAKE ONTARIO
St Lawrence River
Massena
Ogdensburg
RAQUETTE R.
OSWEGATCHIE R.
Watertown
BLACK R.
Oswego
OSWEGO R.
ONEIDA L.
Syracuse
BARGE
CANAL
SENECA R.
SKANEATELES L.
OWASCO L.
CAYUGA L.
SENECA L.
KEUKA L.
Ithaca
CANANDAGUA L.
Rochester
GENESSE R.
Hamilton
Lockport
Niagara Falls
BUFFALO
LAKE ERIE
OHIO
PENNSYLVANIA
NEW YORK
FIGURE 3E1

The Barge Canal, successor to historic Erie Canal, runs in a generally east-west direction across the Program Area, as shown on Figure 3-1. The canal provides an inland waterway connection between the Great Lakes at Buffalo and at Oswego, and the Atlantic Ocean via the Hudson River. It crosses many local tributary streams, sometimes connecting with them and in somce cases physically separated. In other parts of its course the Barge Canal coincides with natural rivers and lakes.

The Black River drainage basin is pear-shaped, being about 80 miles long and 25 miles wide at the west end, and 50 miles wide at the east end. The Black River originates via numerous small tributaries on the western slopes of the Adirondack Mountains. The river flows in a north and west direction and enters Lake Ontario near Watertown.

The United States portion of the St. Lawrence River Drainage Basin is not tributary to Lake Ontario, but two tributaries to the St. Lawrence River, the Oswegatchie and the Raquette Rivers, have their headwaters in the Adirondack Mountains. Both Rivers empty into the St. Lawrence; the Oswegatchie at Ogdensburg, and the Raquette at Massena. This basin is triangular in shape and each side is approximately 85 miles long. One side forms the United States-Canadian Boundary. The Oswegatchie River is 90 miles long and the Raquette River is 75 miles long.

The Niagara River discharges approximately 203,000 cubic feet per second (cfs) of water into Lake Ontario with other tributaries discharging another 35,000 cfs to the Lake. The St. Lawrence River receives 241,000 cfs from the Lake.

About 30 inches of precipitation is recorded in the watershed annually. On the average, direct precipitation on the Lake is approximately offset by annual evaporation from the Lake surface.

Population

The 1960 population of the study area was approximately 2.1 million. The total municipal population was approximately 69.4 per cent of this figure. Major cities in the study area and their 1960 population are shown below in Table 3-2. Major subbasin populationsare shown in Table 3 3.

As shown in Table 3-4, the study area population is projected to increase more than two-fold by 2020, at which time it is estimated that about 80 percent of the population will be municipal.

TABLE 3-2

Population of Major Cities

City	1960 Population
Rochester (Metropolitan)	586,000
Syracuse (Metropolitan)	423,000
Niagara Falls	103,500
Auburn	35,249
North Tonawanda	35,000
Watertown	33,346
Ithaca	28,799
Lockport	26,000
Oswego	22,155

TABLE 3-3

Population of Major Subbasins

Basin	1960 Population
Niagara River	115,000
Genesee River	652,000
Oswego River	864,000
Black River	74,000
St. Lawrence River	126,000
Lake Ontario - Minor Tributaries	248,000
Total	2,079,000

TABLE 3-4

Population Projections
Lake Ontario Study Area

Year	1960	1980	2020
Total Watershed Population	2,079,000	2,727,000	4,310,000
Estimated Municipal Population	1,449,000	1,963,000	3,460,000
Per cent of Total Pupulation that is Municipal	69	72	80

Economy

Some elements of the economy which depend upon the water resources of the study area are manufacturing, agriculture, commerce, and tourism.

Manufacturing

The manufacture of food and kindred products is the major water using industry in the study area. Analysis of the area's economy indicate that this industry is likely to remain as the dominant manufacturer in the future.

Primary metals producers are second in employment of the major water using industries. By 2020 they are predicted to increase in employment and still remain in second place. The industries are located principally in the northwest counties of the State and in the Syracuse area.

Agriculture

Much of the watershed area is predominately farm and forestland even though industrial manufacturing and urbanization seem to be taking over. Food related industries depend on the raw materials produced by the area in the form of vegetables, fruit, (apples, cherries, grapes) dairy and poultry products, and livestock. The majority of these agricultural activities take place in the hinterland south and east of Lake Ontario.

Commerce

Rochester, Oswego and Sodus Bay are the major vessel docking areas on Lake Ontario. The port facilities for the Niagara Frontier Area are located on Lake Erie in the Buffalo Area. The harbors cater to interstate and international trade. Some 1,000 ships per season use the New York State Ports.

Tourism

Niagara Falls, the Rochester beach areas, the Ontario lake front, State parks, and the Finger Lake areas, are important from a recreational use standpoint. Niagara Falls is of particular value to the area because of its scenic beauty. The beaches draw transients to the area and the Finger Lakes with their lake shore cottages bring the summer-long inhabitants and the fishermen. Except for the densely populated Rochester area, the Niagara Falls industrial complex, the Syracuse Metropolitan Area, and a number of the larger cities on the Finger Lakes, most of the study area is of low population density and is expected to continue as such. Thus, the Lake Ontario Basin area will remain an important haven for tourists.

CHAPTER 4

WATER USES

Municipal Water Supply

Present use by municipal water supply systems in the Lake Ontario Basin is approximately 307 MGD. The total number of persons served by these systems is 1,983,000. Table 4-1 summarizes the municipal supplies for each of the major basins.

Table 4-2 is a summary of the major sources for both municipal and industrial water supplies. Over 257 MGD or 80 per cent of the municipal water used comes from the twelve surface waters listed. Lake Ontario is by far the largest source of surface water for municipal systems, with over 53 MGD drawn daily in 1965. The Rochester and Oswego areas are the largest customers, presently drawing 30 MGD and 8 MGD, respectively. The Syracuse area will soon be using Lake Ontario water upon completion of a 50 MGD capacity water treatment and transmission works by the Onondaga Water Authority. The Finger Lakes are also sources for large systems. The City of Rochester draws 36 MGD from Canadice and Hemlock Lakes; the Syracuse area takes over 41 MGD from Skaneateles Lake and nearly 20 MGD from Otisco Lake. The Cities of Niagara Falls and Lockport draw over 63 MGD from the Niagara River. Fish Creek, a tributary of Oneida Lake, supplies the City of Rome with over 13 MGD.

Industrial Water Use

Self-supplied industrial water use by the 27 major users presently totals 625 MGD. An undetermined additional quantity, estimated at 100 MGD, is utilized by the smaller industries.

The largest sources for industrial water, as well as for municipal supplies, are listed in Table 4-2. Lake Ontario supplies two large thermal electric power plants with 160 MGD each and Eastman Kodak with 26 MGD for a total of 346 MGD. Onondaga Lake water is used by Allied Chemical and Crucible Steel. These industries report drawing more than 100 MGD. Paper mills on the Black River draw approximately 74 MGD from that stream. Industries on the Niagara River use 41 MGD of its water; a complex of industries at Fulton use 28 MGD from the Oswego River; and the St. Lawrence supplies more than 36 MGD to industries at Ogdensburg and Massena.

Recreation

Extensive recreational use is made of the waters within the Lake Ontario and St. Lawrence River Basin. Poor water quality, however, seriously limits water contact activities in many streams and lakes, particularly the Oswego, Seneca, Genesee, and Black Rivers, the Barge Canal, and Onondaga Lake.

Table 4-1

SUMMARY OF MUNICIPAL WATER SUPPLY
IN THE LAKE ONTARIO BASIN

BASIN	POPULATION SERVED	WATER CONSUMPTION - MGD SURFACE	GROUND	TOTAL
Niagara	107,995	52.00		52.00
Genesee	671,819	84.67	9.25	93.92
Oswego	827,425	111.25	9.15	120.40
Black	59,725	7.52	0.52	8.04
St. Lawrence	66,085	11.08	0.24	11.32
Minor Tributaries	250,071	18.88	2.31	21.19
TOTALS	1,983,120	285.40	21.47	306.87

Table 4-2

MAJOR SOURCES OF MUNICIPAL AND
INDUSTRIAL WATER
IN THE LAKE ONTARIO BASIN

SOURCE	WATER DEMAND - MGD INDUSTRIAL	MUNICIPAL	TOTAL
Canandaigua Lake		3.9	3.9
Seneca Lake		3.6	3.6
Lake Ontario	346**	53.2	399.2
St. Lawrence River	36	5.8	41.8
Fish Creek		13.2	13.2
Niagara River	41	67.0	108.
Canadice and Hemlock Lakes		36.0	36.
Otisco Lake		19.4	19.4
Black River	74	4.5	78.5
Skaneateles Lake		41.6	41.6
Owasco Lake		8.7	8.7
Onondaga Lake	100		100.
Oswego River	28		28.
	625*	257.5	882.5

* Only the 27 largest self-supplied industrial water users are included in the total listed.

** Both Rochester Gas and Electric and Niagara Mohawk have thermal electric plants on the Lake, each drawing 160 MGD. Eastman Kodak draws the remaining 26 MGD.

The Lake Ontario shoreline is approximately 290 miles long and its excellent boating, bathing and fishing make it an outstanding recreation attraction. In 1965, the 12 public parks on the shoreline with swimming available had almost 3,000,000 attendance. It is estimated that 60 per cent of the park attendance used the swimming facilities. The most popular parks with beaches, and their respective 1963 annual attendance figures, are Hamlin Beach State Park (281,000), Ontario Beach (610,000), Durand Eastman Park (950,000), and Webster Beach Park (100,000) - all in the Rochester area; Fairhaven Beach State Park (289,243), and Selkirk Shores State Park (209,800) - just west and east of Oswego respectively. More than 4,500 pleasure craft are moored at 45 commercial marinas and yacht clubs. Many more pleasure craft ply the Lake but are not moored there. Most boating activity centers around Rochester, Sodus Bay, Oswego, and Henderson Bay. Sport fishing is most popular in the eastern end of the Lake.

The inland lakes in the Oswego and Genesee River Basins are numbered among the principal recreational attractions of the Country. Known generally as the Finger Lakes (Onondaga and Oneida are not considered Finger Lakes, but are included here for convenience), these glacial lakes offer vast quantities of fresh water for all water contact activities. Seneca, Cayuga, and Oneida Lakes are the largest, with surface areas of 70 to 80 square miles each. More than 57 state and local park facilities are located adjacent to these Lakes. In 1963 the attendance at these parks was greater than 4,200,000. More than half of this attendance was recorded at the park areas adjacent to and on tributaries of Oneida and Onondaga Lakes. Onondaga Lake Park had over 700,000 visitations in 1963. Great pressure exists on both of these Lakes for their use by pleasure craft. Over 5,000 boats have been reported using Oneida on a single day. Onondaga Lake is the scene of the annual Intercollegiate Rowing Regatta.

The State Barge Canal System is another of the Basin's valuable recreational assets. Because of its poor water quality, however, its use is mostly limited to boating, although fishing is popular in selected areas. Over 100 small boat marinas are estiblished along the canal system. Pleasure boating has more than quadrupled in the last fifteen years, as indicated by the number of permits issued for lockage. The State Department of Public Works reported issuing 2,000 such permits in 1952 and over 10,000 in 1965. An estimated additional 30,000 craft use the canal system between the locks.

Hydro Power

The public and industrial hydroelectric facilities in the Lake Ontario Basin have a combined capacity of approximately three million kilowatts for use both in and outside of the Basin. This includes the large facilities on the Niagara and St. Lawrence Rivers.

The Genesee, Oswego, Black, and Minor Tributary Basins contain 54 hydroelectric facilities for which data are available. The total capacity for those plants listed as wholly industrial is only ten per cent of the total.

All of the major streams in the St. Lawrence Basin, with the exception of the St. Lawrence, were at one time harnessed for power. As an example, in 1936, there were 20 public and 14 industrial utilities on the Oswegatchie River. Now these plants are being abandoned as the new Power Authority facility on the St. Lawrence and five new plants on the Racquette River have become the main sources of electrical energy for the area.

At the eastern and western extremities of the Ontario Basin are located two huge hydroelectric facilities operated by the New York State Power Authority. The St. Lawrence plant is operated jointly by the Power Authority and an equivalent Canadian Agency. The St. Lawrence plant has a capacity of 1,400,000 KW from its 32 generators. Sixteen of these generators produce electricity for the Power Authority. The Niagara plant has a capacity of 1,800,000 KW and all of the energy produced is consumed within the United States. These two plants are tied in with Consolidated Edison at Utica and together form the backbone of the New York State Power complex.

Commercial Shipping

During 1965, an estimated three million tons of cargo were handled by Lake Ontario Ports in New York State. An estimated 1,000 ships visited the Ports of Rochester, Great Sodus, and Oswego. The principal commodities handled at Rochester are coal and cement; at Great Sodus, mostly coal, and at Oswego, coal, grain, and petroleum products. Data on cargo movement through the St. Lawrence Seaway indicated that, in 1965, more than 43 million tons of cargo were transported through Lake Ontario on 3,700 ships.

The use of the Barge Canal for freight traffic has remained constant over the last 15 years. Total freight tonnage in 1962 was approximately 1,500,000 and the number of boats carrying this tonnage was about 750. The average tonnage between the years 1947 and 1951 was 1,400,000. The eastern section of the Canal between Oswego, Syracuse, and Albany is the most heavily used.

Commercial Fishing

The commercial fish catch in Lake Ontario is the smallest in the Great Lakes. Ninety per cent of the annual Lake catch is captured by Canadian interests. The total pounds of fish reported by United States fisheries ranged from 233,000 to 351,200 during the years 1960 - 64. Yellow perch, carp, eels and white perch are the principal species caught.

Present Classification of Basin Waters

New York State has just recently completed a program of classification of its streams. The classes of water vary from A to F with the respective best uses designated as drinking water supply, bathing, fishing, agricultural or industrial, and sewage and industrial waste disposal, in that order.

The majority of the waters in the Basin area are classified B or C. Most of the inland lakes, with the exception of Onondaga, are generally A or B. Dry weather streams and stretches of streams below sizeable waste discharges are generally D. The few streams that are E or F, such as reaches on Nine Mile Creek, Ley Creek and Honeoye Creek, are in the process of being upgraded.

While the existing method and scope of classification of streams by New York State has done much overall for up-grading the waters in the Lake Ontario Basin, it is known that a broader and more ambitious set of water quality objectives and pollution control procedures must be adopted if the maximum usage of the streams is to be realized. Under the present procedures for classifying waters, the State Health Department is often unable to bring an abatement action against an industry or municipality unless its discharge stands alone and causes very obvious nuisance conditions. In other cases even very gross pollution is excused under the State Classifications by allowing special or very low quality to exist for a convenient stretch below an existing major pollution source. Another incongruity is the sudden change of purification that is expected of many streams. Situations have been noted where a stream, classified to permit municipal and industrial waste discharges, abruptly changes to a classification suitable for swimming, with inadequate distance for the transition to higher quality to be accomplished.

CHAPTER 5

WASTE SOURCES

Municipal Wastes

In the study area there are a total of 169 municipal sewage treatment facilities serving a population of over 1,544,000. Many communities have no treatment facilities, including the Cities of Watertown, Fulton and Oswego which have a combined population of nearly 70,000.

The waste load to the basin streams from all municipal sources is estimated to have a total population equivalent (PE) of 2,299,000 (in terms of oxygen consuming capacity). A summary of these discharges is outlined in Table 5-1. Of the total it is estimated that 177,000 PE is discharged by communities having no treatment facilities. The remaining 2,122,000 population equivalent is the resultant discharge from all municipal treatment facilities. The raw influent to the treatment facilities is that from an equivalent population of nearly 3,900,000 people. Comparing this latter figure against the population served, one gains an appreciation of the significant effect of industrial connections on the basin's municipal waste systems. Also shown in Table 5-1, the overall degree of treatment in the basin as a whole is approximately 41 per cent. There are 118 primary plants and 51 secondary plants. All of the larger plants are of the primary type, including the City of Rochester's large plant which discharges to Lake Ontario. Figure 5-1 is a summary of the treatment facilities of all communities with connected populations over 10,000.

In the Lower Niagara River the only major discharge is that of the City of Niagara Falls. This is a particularly ineffective plant. Extremely overloaded by industrial waste, it receives the waste from an equivalent population of nearly 450,000 while serving only 110,000 people. Its treatment efficiency with this high loading has been measured at about 15 per cent (BOD reduction). The City of Lockport also has an ineffective plant overloaded by industrial waste. The plant is of the primary type and is treating at only 33 per cent efficiency.

The primary treatment plant operated by the City of Rochester, the largest plant in the Basin, receives a raw waste equivalent to that from nearly 1,800,000 although it serves a population of only 375,000. Its discharge after 46 per cent treatment is directly to Lake Ontario. The City of Syracuse also discharges a large loading with only primary treatment. Its two plants receive approximately 325,000 PE and discharge over 200,000 PE to Onondaga Lake for a net reduction of only 40 per cent. The City of Auburn has an ineffective plant treating only 35 per cent of an influent 98,000 PE. Watertown is presently building a primary treatment plant for its 40,000 plus population - heretofore discharged raw to the Black River. Only the City of Ithaca and the Communities of Newark, Brighton, Canandaigua, Brockport, East Rochester, Greece, Irondequoit (part), and Henrietta have adequate secondary

Table 5-1

SUMMARY OF MUNICIPAL WASTE DISCHARGES
TO SURFACE WATERS OF THE
LAKE ONTARIO BASIN

MUNICIPALITY	RECEIVING STREAM	EXISTING TREATMENT	POPULATION SERVED	POPULATION EQUIVALENT BOD BASIS		PER CENT REDUCTION
				INFLUENT	EFFLUENT	
		BLACK RIVER BASIN				
Watertown	Black River	None	34,000	40,800	40,800	0
All Others			15,600	17,200	17,200	0
TOTALS			49,600	58,000	58,000	0
		GENESEE RIVER BASIN				
Dansville	Canaseraga Creek	Primary	5,460	3,780	2,520	33
Irondequoit (St. Paul)	Genesee River	Primary	5,500	5,500	3,600	35
LeRoy	Oatka Creek	Primary	4,800	5,000	3,250	35
Monroe County Sewer Agency (Gates, Chili, Ogden)	Genesee River	Primary	15,000	16,200	10,600	35
Perry	Silver Lake Outlet	None	4,500	4,500	4,500	0
Wellsville	Genesee River	Primary	6,000	7,470	6,200	17
All Others			31,340	46,550	24,330	48
TOTALS			72,600	89,000	55,000	38
		LAKE ONTARIO				
Rochester Main Plant	Lake Ontario	Primary	375,000	1,760,000	945,000	46
All Others			6,000	6,000	6,000	0
TOTALS			381,000	1,766,000	951,000	46

Table 5-1 (cont'd.)

MUNICIPALITY	RECEIVING STREAM	EXISTING TREATMENT	POPULATION SERVED	POPULATION EQUIVALENT BOD BASIS		PER CENT REDUCTION
				INFLUENT	EFFLUENT	
		MINOR TRIBUTARY BASINS				
Albion	West Branch Sandy Creek	Secondary	5,180	5,000	750	85
Brighton S. D. # 2	Allen Creek	Secondary	23,000	25,200	5,860	77
Brighton S. D. # 4	Irondequoit Creek	Secondary	10,500	7,000	400	94
Brockport	Brockport Creek	Secondary	8,000	20,000	7,000	65
East Rochester	Irondequoit Creek	Secondary	8,152	15,000	5,000	67
Fairport	Thomas Creek	Secondary	5,400	8,000	2,500	69
Greece Sewer District # 1	Slater Creek	Secondary	35,000	25,000	3,750	85
Henrietta S. D. # 1	Barge Canal	Secondary	12,000	12,000	1,800	85
Irondequoit N. E.	Irondequoit Bay	Secondary	11,600	11,600	1,740	85
Lockport	Eighteenmile Creek	Primary	25,135	37,500	25,000	33
Medina	Oak Orchard Creek	Primary	7,000	7,000	4,250	39
Oswego	Lake Ontario	None	6,000	6,000	6,000	0
Rochester East Trunk Sewer	Thomas Creek	None	12,000	18,000	18,000	0
All Others			43,933	58,700	31,950	46
TOTALS			212,900	256,000	114,000	55
		NIAGARA RIVER				
Niagara Falls	Niagara River	Primary	110,000	482,000	409,000	15
All Others			5,700	6,000	4,000	33
TOTALS			115,700	488,000	413,000	15
		OSWEGO RIVER BASIN				
Auburn	Owasco Outlet	Primary	40,000	98,000	63,700	35

Table 5-1 (cont'd.)

MUNICIPALITY	RECEIVING STREAM	EXISTING TREATMENT	POPULATION SERVED	POPULATION EQUIVALENT BOD BASIS		PER CENT REDUCTION
				INFLUENT	EFFLUENT	
OSWEGO RIVER BASIN (cont'd.)						
Baldwinsville, North Plant	Seneca River	Primary	8,000	9,250	6,000	35
Camillus	Nine Mile Creek	Primary	12,000	12,000	7,800	35
Canandaigua City	Canandaigua Outlet	Secondary	10,000	15,000	2,250	85
Canastota	Canastota Creek	None	5,000	5,000	5,000	0
Fulton	Oswego River	None	14,000	21,000	21,000	0
Geneva City	Seneca Lake	Primary	16,285	19,000	12,350	35
Ithaca	Cayuga Inlet	Secondary	35,000	35,000	5,250	85
Marcellus	Nine Mile Creek	Primary	5,000	4,500	3,800	16
Newark	Military Creek	Secondary	12,870	15,000	2,250	85
Oneida	Oneida Creek	Primary	12,000	12,000	6,600	45
Onondaga Co. (Ley Creek)	Ley Creek	Primary	74,500	200,000	75,000	65
Oswego	Oswego River	None	8,900	6,000	6,000	0
Penn Yan	Keuka Outlet	Secondary	5,770	41,600	5,240	87
Seneca Falls	Seneca River	Primary	7,440	5,500	4,700	15
Syracuse (Main Plant)	Onondaga Lake	Primary	250,000	260,000	130,000	50
Watkins Glen	Seneca Lake	Primary	5,000	5,000	3,250	35
All Others			117,635	384,150	277,810	28
TOTALS			639,400	1,148,000	638,000	44
ST. LAWRENCE RIVER BASIN						
Gouverneur	Oswegatchie River	None	4,800	4,800	4,800	0
Massena	Grass River	Primary	15,785	25,000	16,250	35
Ogdensburg	St. Lawrence River	Primary	16,345	16,500	10,620	35
Potsdam	Racquette River	None	6,930	14,000	14,000	0
Tupper Lake	Racquette Pond	Primary	5,200	5,200	3,400	35

Table 5-1 (cont'd.)

MUNICIPALITY	RECEIVING STREAM	EXISTING TREATMENT	POPULATION SERVED	POPULATION EQUIVALENT BOD BASIS		PER CENT REDUCTION
				INFLUENT	EFFLUENT	
	ST. LAWRENCE RIVER BASIN (cont'd.)					
All Others			24,440	23,500	20,930	11
TOTALS			73,500	89,000	70,000	15
TOTALS FOR BASINS			1,544,700	3,894,000	2,299,000	41

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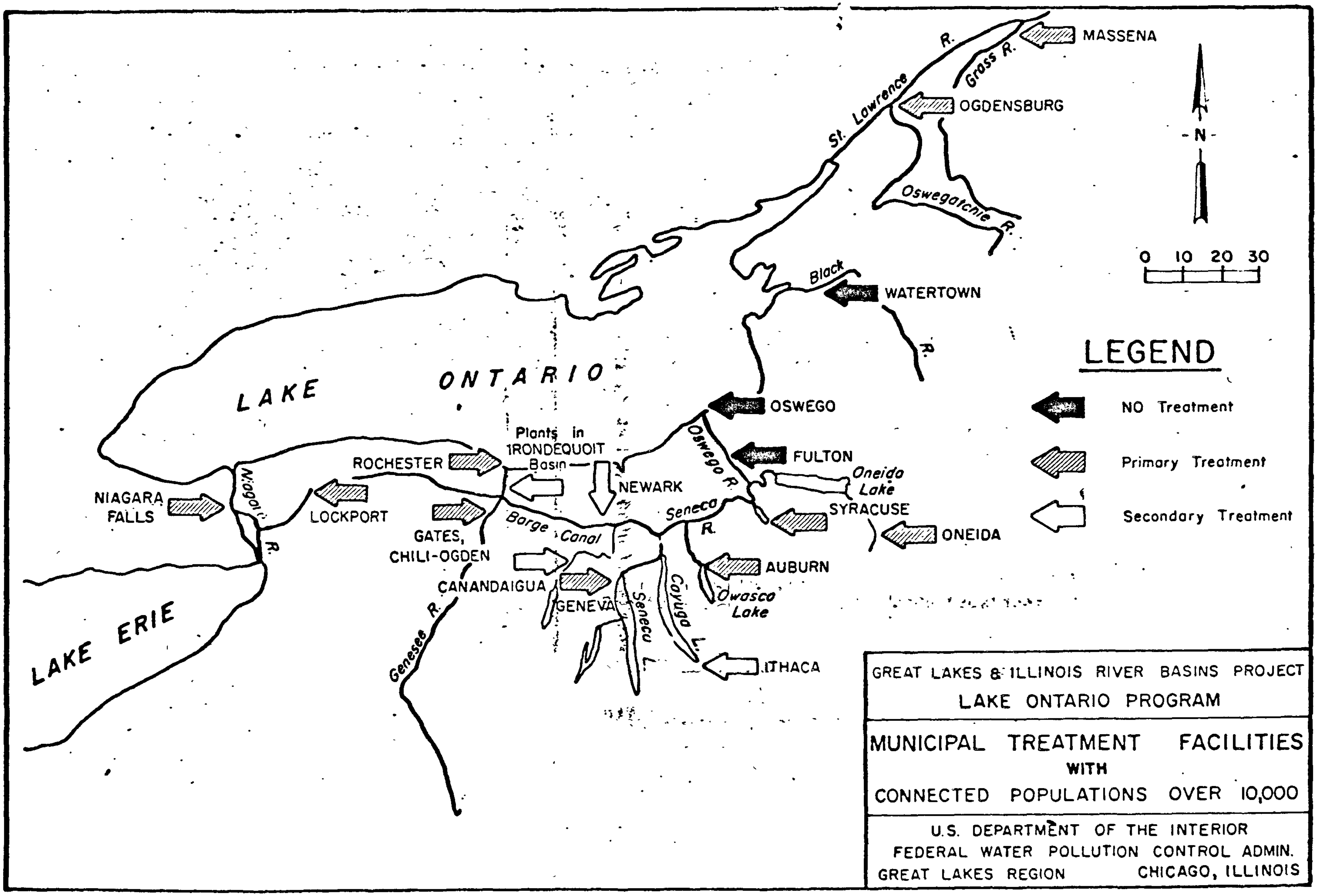


MASSENA
Grass R.
St. Lawrence R.
OGDENSBURG
Oswegatchie R.
Black
WATERTOWN
R.
LAKE ONTARIO
OSWEGO
FULTON
Oswego R.
Oneida Lake
SYRACUSE
ONEIDA
Seneca R.
AUBURN
Owasco Lake
Cayuga L.
Seneca L.
ITHACA
GENEVA
CANANDAIGUA
NEWARK
Plants in IRONDEQUOIT Basin
Barge Canal
ROCHESTER
GATES, CHILI-OGDEN
Genesee R.
LOCKPORT
Niagara R.
NIAGARA FALLS
LAKE ERIE
N
0 10 20 30
LEGEND
NO Treatment
Primary Treatment
Secondary Treatment
GREAT LAKES & ILLINOIS RIVER BASINS PROJECT
LAKE ONTARIO PROGRAM
MUNICIPAL TREATMENT FACILITIES
WITH
CONNECTED POPULATIONS OVER 10,000
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
GREAT LAKES REGION CHICAGO, ILLINOIS

FIGURE 5-1

plants. See the summary on Table 5-1 for the remaining major municipal discharges with connected populations over 5,000.

Industrial Waste

There are approximately 300 industries in the Lake Ontario and St. Lawrence Basins that discharge their wastes directly to surface waters. Only a few of the industries provide some degree of treatment to their waste before discharge. In no case does an industry provide treatment on the par of a secondary municipal sewage treatment facility. The total industrial waste load generated in the Basin is estimated at 2,627,000 population equivalents, BOD basis. While the organic waste loading in terms of BOD represents the major pollution effect on the streams, there are also discharges of suspended solids, chlorides, toxic metals, phenols, dyes and many other pollutants that are causing gross degradation.

Summarized in Table 5-2 is a list of the 52 major industrial polluters in the basin. All of these have either an effluent of 1,000 pounds per day of 5-day BOD (the equivalent of a population of 5,000 - 6,000) or a waste high in phenols, suspended solids, etc.. Only eight of these large waste producers effect any degree of treatment on their process waste. The total PE loading from these industries alone is 2,537,000 or 96 per cent of the total industrial PE discharged in the basin. These industries also represent about 80 per cent of the total industrial waste volume generated in the Basin.

Paper mills and paper products plants, canneries, dairies, and other food processing plants, and chemicals and allied products plants are the worst offenders in the Basin. An Allied Chemical-Solvay Division plant at Syracuse treats only a fraction of its waste in tailing ponds. The plant's discharge to Onondaga Lake draws heavily on the Lake's oxygen reserves and deposits vast quantities of carbonates and chlorides (approximately 4,000 tons per day) to the Lake. Lower Nine Mile Creek is also grossly polluted by this plant's discharge. A complex of paper mills, notably St. Regis and Georgia Pacific, discharge an organic loading to the Black River equivalent to more than 640,000 people, degrading the stream seriously. Another industrial complex at Fulton pollutes the Oswego River to the extent that its oxygen resources are often critically depleted. Sealright Container Corporation, Nestles Chocolate, Birdseye Division of General Foods, Armstrong Cork and North End Paper all discharge raw wastes within two miles of each other to the tune of 121,000 PE. Eastman Kodak at Rochester grossly pollutes the Lower Genesee River with 330,000 PE of partially treated waste. Five industries, Union Carbide, Hooker Chemical, International Paper, Olin Mathieson and DuPont, discharge a combined raw waste through a diversion sewer just below the American Falls on the Niagara River that has been estimated at 37 MGD and having a PE greater than 300,000.

Combined Sewers

Overflows from combined sewer systems are a significant factor in the

Table 5-2

MAJOR INDUSTRIAL DISCHARGES
DIRECT TO SURFACE WATERS
OF THE
LAKE ONTARIO BASIN

INDUSTRY LOCATION	RECEIVING STREAM	EXISTING TREATMENT	WASTE EFFLUENT MGD	LBS BOD_5/DAY	POPULATION EQUIVALENT
Aiello Dairy Heuvelton	Oswegatchie River	None	0.60	6,000	36,000
Alcoa Massena	Grass River	Lagoons	19.0	900 (6,900 LBS PHENOLS/DAY)	5,400
Allied Chemical Solvay Division Syracuse	Onondaga Lake	None	80.	33,400 (33,400 LBS/day COD)	200,400
	Nine Mile Creek	Tailing Pond	80.	12,100 (31,800 LBS/day COD)	72,600
Armstrong Cork Fulton	Oswego River	None	4.45	7,350	44,100
Bordens Pioneer Ice Cream Division Gouverneur	Oswegatchie	None	0.22	3,000	18,000
Bordens Foods Mexico	Little Salmon River	None	1.1	2,300	13,800
Brownville Board Brownville	Black River	None	1.	1,000	6,000
Brownville Paper Brownville	Black River	None	1.	1,000	6,000
Carborundum Corp. Niagara Falls	Niagara River	None	2.4	7,300	42,800
Carthage Paper Makers, Inc. West Carthage	Black River	None	7.74	8,900	53,400
Columbia Mills Minetto	Oswego River	None	.49	2,000	12,000

Table 5-2 (cont'd.)

INDUSTRY LOCATION	RECEIVING STREAM	EXISTING TREATMENT	WASTE EFFLUENT MGD	LBS BOD_5/DAY	POPULATION EQUIVALENT
Crown Zellerback Paper Carthage	Black River	None	5.35	6,400	38,400
Curtice Burns Bergen	Black Creek	Spray irrigation	0.54	7,600	45,600
Curtice Burns Cannery Mt. Morris	Genesee River	None	.36	2,250	13,500
Diamond Gardener Ogdensburg	St. Lawrence River	None	4.0	6,750	40,000
Duffy Mott Williamson	Salmon Creek	None	2.5	10,300	61,800
DuPont, E. I. Niagara Falls	Niagara River	None	*	13,400	80,400
Eastman Kodak Rochester	Genesee River	Primary	26.	55,000	330,000
Edgett and Burnham Cannery Newark	Barge Canal	None	.04	2,000	12,000
Empire State Sugar Montezuma	Barge Canal	Lagoons	2.0**	8,000	48,000
Evans Chemetics Waterloo	Seneca River	None	3.25	10,300	61,800
Flintkote Co. Lockport	Eighteenmile Creek	None	0.5	2,100	12,600

* Total waste flow of International Paper, Olin Mathieson, DuPont, Union Carbide, and Hooker discharged through one diversion sewer, estimated at 37 MGD

** Discharge only in spring months

Table 5-2 (cont'd.)

INDUSTRY LOCATION	RECEIVING STREAM	EXISTING TREATMENT	WASTE EFFLUENT MGD	LBS BOD_5/DAY	POPULATION EQUIVALENT
General Foods Birds Eye Division Avon	Genesee River	None	1.	16,700	100,000
General Foods Birds Eye Division Fulton	Oswego River	None	.95	1,600	9,500
General Motors Chevrolet Division Roosevelton	St. Lawrence River	Oil separation	2.64	300 (1450 LBS COD/day) (77 LBS PHENOLS/day)	1,700
General Motors Harrison Radiator Division Lockport	Eighteenmile Creek	Oil separation	1.61	1,500 LB Zn/day 280 LB Cu/day 200 LB Fl/day	
Georgia Pacific Gould Division Lyons Falls	Black River	None	20.3	36,900	221,000
Hammermill Paper Oswego	Lake Ontario	None	2.47	4,100	24,600
Hooker Chemical Niagara Falls	Niagara River	None	*	22,800	136,800
International Paper Niagara Falls	Niagara River	None	7.85*	13,100 (42,300 LB COD/day)	98,600
Knowlton Paper Watertown	Black River	None	3.6	1,000	6,000
Lewis, J. P. Beaver Falls	Black River	None	6.6	6,200	37,200
M. P. Amusement Suburban Park Manlius	Limestone Creek	None	.95	1,600	9,600

* Total waste flow of International Paper, Olin Mathieson, DuPont, Union Carbide, and Hooker discharged through one diversion sewer, estimated at 37 MGD

Table 5-2 (cont'd.)

INDUSTRY LOCATION	RECEIVING STREAM	EXISTING TREATMENT	WASTE EFFLUENT MGD	LBS BOD_5/DAY	POPULATION EQUIVALENT
McIntyre Paper Fayetteville	Limestone Creek	None	1.28	2,100	12,600
Nakoosa Edwards Paper Co. Unionville	Raquette River	None	1.14	2,000	12,000
National Biscuit Lyons Falls	Barge Canal	None	.11	3,500	21,000
Nestles Company Fulton	Oswego River	None	3.0	6,000	36,000
North End Paper Fulton	Oswego River	None	.70	1,100	6,600
Northland Paper Norfolk	Raquette River	None	5.70	8,100	48,600
Olin Mathieson Niagara Falls	Niagara River	None	*	(Total solids 7,700 mg/l)	
Oswego River Tissue Phoenix	Oswego River	None	2.3	3,800	22,800
Perfection Canning Newark	Barge Canal	None	0.20	9,100	54,600
Perry Knitting Perry	Silver Lake	None	.13	1,700	10,000
Reigel Paper Newark	Barge Canal	None	1.26	4,000	24,000
Reynolds Metals Roosevelton	St. Lawrence River	None	9.0	500 (6,700 LBS PHENOL/day)	3,000
St. Regis Paper Deferiet	Black River	None	28.0	46,600	280,000

* Total waste flow of International Paper, Olin Mathieson, DuPont, Union Carbide, and Hooker discharged through one diversion sewer, estimated at 37 MGD

Table 5-2 (cont'd.)

INDUSTRY LOCATION	RECEIVING STREAM	EXISTING TREATMENT	WASTE EFFLUENT MGD	LBS BOD_5/DAY	POPULATION EQUIVALENT
Sealright Container Fulton	Oswego River	None	5.64	4,600	27,600
Stauffer Chemical Lewiston	Niagara River	None	1.84	1,600	9,600
Union Carbide Niagara Falls	Niagara River	None	*	(65,000 LBS SUSPENDED SOLIDS/day)	
United Board and Carton Lockport	Eighteenmile Creek	None	1.95	5,900	35,400
Upson Company Lockport	Barge Canal	Settling	0.85	2,100	12,600
Vanity Fair Paper Gouverneur	Oswegatchie River	None	2.40	3,600	21,600

* Total waste flow of International Paper, Olin Mathieson, DuPont, Union Carbide, and Hooker discharged through one diversion sewer, estimated at 37 MGD

pollution of many of the streams and lakes in the Basin. The systems at Rochester and Syracuse are the most serious polluters in this regard. The other major cities also discharge raw sewage during storm overflows except the City of Ithaca, which has a separate system.

Sixty per cent of the City of Rochester's sewers are of the combined type. Thirty-three overflows from their combined system discharge when two and one half times the dry weather flow is exceeded. Thirty of these overflows discharge to the Genesee River and three to Irondequoit Bay. Four of these overflows receive chlorination prior to discharge and chlorination facilities are planned for four more.

The sewers of the City of Syracuse are almost all of the combined type. Syracuse's eight miles of main interceptors have 64 possible overflow points to Onondaga Creek and Harbor Brook. The interceptors are designed to handle about two times the City's 40 MGD dry weather flow, but due to negligent maintenance, the subsequent deterioration of the overflow chambers, and the buildup of grit in the interceptors, many of the overflow outlets discharge continuously. In October of 1957, New York State Department of Health conducted a survey which indicated that approximately 40 per cent of the total sanitary sewage flow in the City was being discharged directly to the streams without interception and treatment. A report in 1961 by an engineering consultant of the improvement needs in the sewer system revealed the situation had not changed greatly. They found twelve overflows discharging raw sewage continuously and nine intermittently. The consultant engineers designated the cause as a lack of maintenance of the interceptor connections and a buildup of an estimated 2,300 cubic yards of grit in the interceptors, greatly decreasing their capacity.

Vessel Pollution

During 1965, about 1,000 commercial vessels visited Rochester, Sodus, and Oswego and probably remained in port from one to two days. Pleasure craft in Lake Ontario presently number some 4,500 permanently moored and many more in transit.

Pollution discharged from commercial vessels and small craft is not generally a significant problem compared to discharges from municipalities and industries unless concentrated in a bay or near beaches. Many of the marinas are located in protected covelike locations, however, such as Irondequoit and Sodus Bays, where garbage and other debris often produce unsightly, littered waters.

Land Runoff

Loss of soil, fertilizers and pesticides is of increasing concern with regard to the quality of the Basin's streams, inland lakes and, especially, Lake Ontario. Water erosion of soil particularly severe in the Honeoye Creek

watershed in the Genesee Basin and extensive sections of the Seneca, Keuka, Canandaigua, and Clyde River drainage basin. Moderate erosion takes place in the entire Genesee Basin. The high turbidity of the Genesee River in the spring months is a result of this erosion.

Pesticides are used extensively in the fruit belt east and west of Rochester along the Lake shoreline. Determinations as to the amount of these pesticides reaching the streams of the area and Lake Ontario are incomplete. Some minor application of pesticides is practiced in the Finger Lakes region, and analysis of samples from Cayuga and Seneca Lakes is accordingly forthcoming.

Fertilizers are applied in significant amounts to many areas of moderately productive solids. Improper application, particularly in the spring, can result in the excessive loss of fertilizers to the streams. A program is underway to determine the amount of phosphates and nitrogens that reach Lake Ontario as a result of runoff from rural lands.

Federal Installations

There are 60 Federal Installations in the Lake Ontario Basin that discharge their wastes directly to surface waters or to the ground. Table 5-3 lists only those installations discharging directly to surface waters. Ground discharges are not included in Table 5-3 because only a small fraction of the total flow from all installations is discharged in this manner. Those installations connected to a recognized sewer system are not included because their loadings would be reflected in the municipal sewage treatment inventory.

The 10 installations listed in Table 5-3 discharge almost one million gallons per day of wastes to surface waters. Five of these installations have secondary treatment facilities, treating approximately 310,000 gallons per day. A total of 50,000 gallons per day is discharged directly to the ground disposal systems from the remaining 50 installations. Two of the larger installations, the Veterans Administration Hospital, Canandaigua, and Camp Drum, are now preparing plans for secondary treatment units. The Air Force Plant No. 38 is working on a proposal to connect to the Niagara Falls municipal system.

Table 5-3

FEDERAL INSTALLATIONS DISCHARGING DIRECTLY TO SURFACE WATERS OF THE LAKE ONTARIO BASIN*

INSTALLATION	AGENCY	RECEIVING STREAM	ESTIMATED WASTE FLOW GPD	TREATMENT
Air Force Plant # 38	Air Force	Threemile Creek	122,000	Minor
Camp Drum	Army	Black River	100,000	Primary
Custom House Ogdensburg	General Services Administration	St. Lawrence River	7,650	Secondary
Lockport Air Force Station	Air Force	Niagara River	80,000	Secondary
Niagara Life-boat Station	Coast Guard	Niagara River	1,000	None
Seneca Ordinance Depot Romulus	Army	Reeder Creek	92,500	Secondary
		Kendaia Creek	90,000	Secondary
		Kendaia Creek	10,000	Secondary**
Snell Lock Overlook	St. Lawrence Seaway Corp.	St. Lawrence River	500	Minor
Verona Test Annex	Air Force	German Creek	4,000	Secondary
Veterans Administration Hospital Canandaigua	Veterans Administration	Canandaigua Lake	340,000	Ineffective Primary
Watertown Air Force Station	Air Force	Sandy Creek	27,500	Secondary

* There are 50 other Federal agency installations discharging a total of 50,000 GPD to ground disposal systems.

** New plant in operation by December, 1966.

CHAPTER 6

WATER QUALITY IN LAKE ONTARIO

Introduction

In the Comprehensive Study of the Water Quality in Lake Ontario, analytical data has been assembled on all parameters which are recognized as significant factors affecting the quality of this water.

Three sampling cruises were conducted covering 42 selected stations on the lake. The cruises were of approximately two weeks duration and were conducted May 10 through 28, July 19 through August 6, and September 13 through October 6, 1965. The sampling, therefore, embraced the spring, summer, and fall seasons. For the purpose of this presentation, the lake has been divided into three sectors; namely, the western, central, and eastern, as shown in Figure 6-1.

Chemical Findings

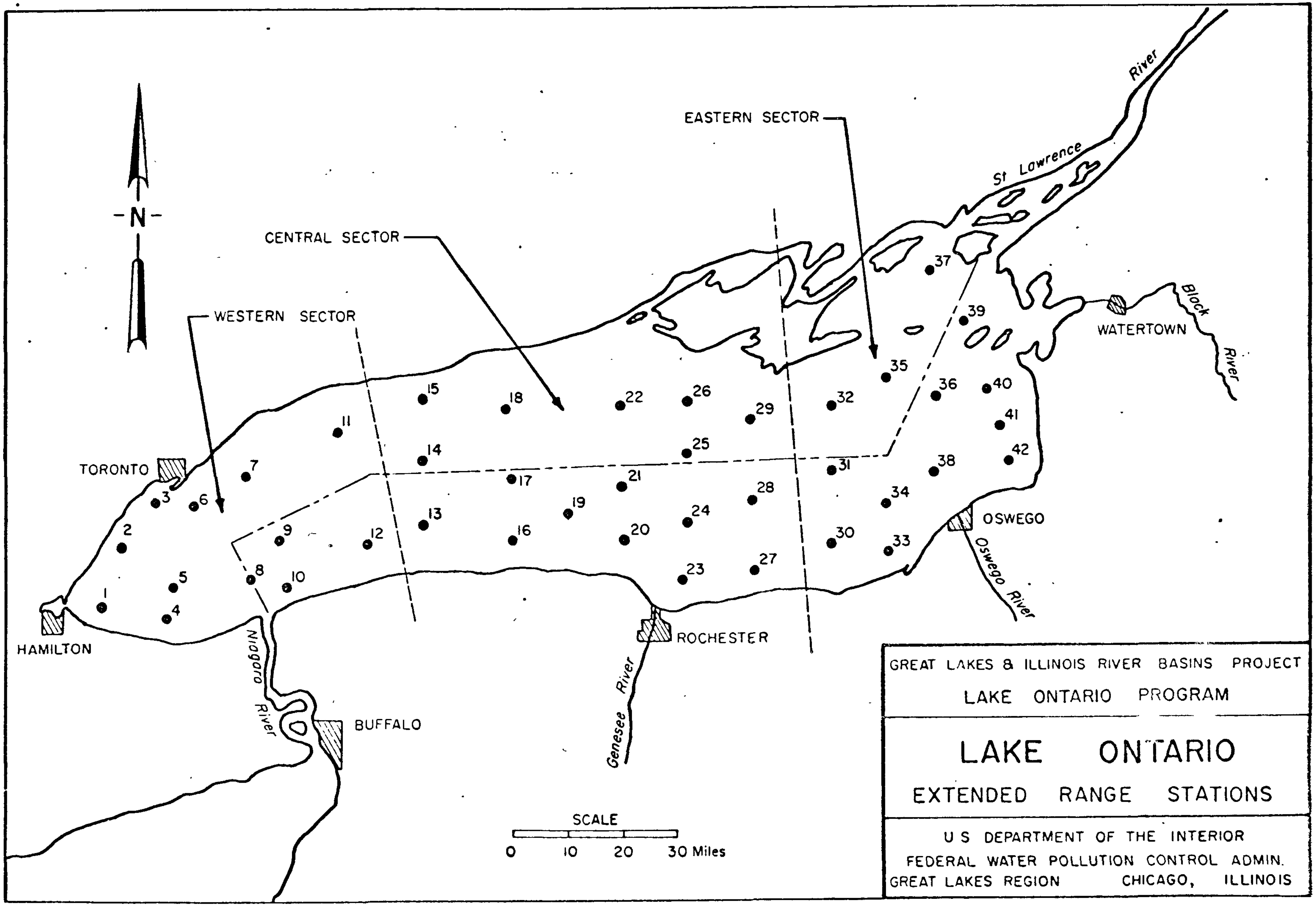
Physical and chemical changes in Lake Ontario are caused by natural phenomena and by the activities of man. The constituents measured in this study reflect those changes, or build-ups, from various natural events, waste-water discharges, and other water uses. A brief discussion of major parameters is given in subsequent paragraphs, and results are summarized in tables at the end of this text.

Hydrogen Ion Concentration (pH)

Most natural waters are slightly alkaline, and Lake Ontario is typical in this respect, with pH values ranging from 7.9 to 9.0 in the western sector and 8.1 to 8.7 in the central and eastern sectors. No appreciable seasonal variations were noted. Similarly, only slight variations were detected in the vertical profiles of all 42 stations sampled.

Alkalinity

Alkalinity, while not important in itself, does serve as a measure of the gross amount of carbonates, bicarbonates, hydroxides, and other anionic groups present in the water. The carbonates and their hydrolytic product (CO_2) serve as a source of carbon for various biological species, thereby affecting the productivity of the lake. The alkalinity values found in this investigation were essentially uniform throughout the entire lake. The average concentration for the western, central and eastern sectors during the spring cruise were 96, 98 and 95, respectively. The values showed a slight increase during the fall cruise, averaging 100, 101 and 94 for the


N
WESTERN SECTOR
CENTRAL SECTOR
EASTERN SECTOR
St Lawrence
River
Block
River
WATERTOWN
TORONTO
HAMILTON
Niagara
River
BUFFALO
ROCHESTER
Genesee
River
OSWEGO
Oswego
River
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SCALE
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10
20
30 Miles
GREAT LAKES & ILLINOIS RIVER BASINS PROJECT
LAKE ONTARIO PROGRAM
LAKE ONTARIO
EXTENDED RANGE STATIONS
U S DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
GREAT LAKES REGION CHICAGO, ILLINOIS

FIGURE 6-1

western, central and eastern sectors, respectively.

Dissolved Oxygen

Table 6-1 summarizes the comparative ranges of dissolved oxygen concentrations for the lake during the three seasons of investigation. These values, for the most part, represent saturation or near saturation concentrations.

Vertical profiles of dissolved oxygen were measured at all of the 42 sampling stations. During the spring season the temperature range from top to bottom was around 3 to 4°C, and there was essentially no thermal stratification. Values of dissolved oxygen showed no significant variation among the three sectors studied. In many, but certainly not in all, cases there was a slight decrease in dissolved oxygen concentrations as the depth increased. However, no zones of even moderate depletion were found.

Biochemical and Chemical Oxygen Demand

The BOD's and COD's were determined at each station in order to get an estimate of organic matter present in the lake. There was essentially no variation in the BOD profiles. Most of the results were less than 1 mg/l. The maximum value to occur was 2.4 mg/l.

The COD concentrations recorded during the spring cruise averaged 8.6 mg/l for the western sector and 6 mg/l for both the central and the eastern sectors. Results of the summer season show almost comparable averages, with values of 7.8, 7.7 and 8.7 mg/l for western, central and eastern sectors, respectively. Concentrations in the fall season for the three sectors were 8.9 mg/l in the western, 5.0 mg/l in the central, and 7.0 mg/l in the eastern sector. The seasonal variation was minimal, and no appreciable difference in geographical distribution of COD was apparent.

Phosphate

Both total and soluble phosphates were determined in this study. The total phosphate was determined by digesting the sample with potassium persulfate in order to free any phosphate which might be a constituent of organic compounds. Because the decision to include the total phosphate was made late in the study, values for this parameter do not appear in the tabulation of the spring cruise. Tables 6-3 and 6-4 show both total and soluble phosphates for the summer and fall cruises.

The average phosphate values are essentially the same for all seasons and at all stations sampled. It is evident that the concentration of this nutrient is approaching the critical level associated with over-production of algae and attendant problems.

Ammonia, Organic and Nitrate Nitrogen

Concentrations of ammonia, organic and nitrate nitrogen were determined at each station throughout the three sampling cruises, and results are also shown in Tables 6-2, 6-3, and 6-4.

There appears to be no particular pattern in the vertical distribution of ammonia concentrations since they varied from station to station with respect to maxima and minima and in relationship to depth. A similar condition existed horizontally in that high and low values were at random throughout each sector.

The average nitrate values were 0.33 mg/l, 0.33 mg/l and 0.36 mg/l for the western, central and eastern sectors, respectively. It is evident that no appreciable variation existed.

Other Parameters

The analyses performed and the ranges found for other parameters are summarized below.

Chlorides, spring season

western sector, range from 24 to 25 mg/l
central sector, range from 24 to 25 mg/l
eastern sector, range from 24 to 27 mg/l

Chlorides, summer season

western sector, range from 22 to 26 mg/l
central sector, range from 23 to 25 mg/l
eastern sector, range from 23 to 25 mg/l

Chlorides, fall season

western sector, range from 23 to 25 mg/l
central sector, range from 23 to 26 mg/l
eastern sector, range from 23 to 26 mg/l

Conductance (Specific), spring season

western sector, range from 270 to 320 micromhos per cm
central sector, range from 301 to 340 micromhos per cm
eastern sector, range from 305 to 350 micromhos per cm

Conductance (Specific), summer season

western sector, range from 300 to 330 micromhos per cm
central sector, range from 275 to 330 micromhos per cm
eastern sector, range from 295 to 324 micromhos per cm

Conductance (Specific), fall season

western sector, range from 300 to 380 micromhos per cm
central sector, range from 270 to 360 micromhos per cm
eastern sector, range from 300 to 330 micromhos per cm

Sodium and Potassium

Sodium and potassium were determined only during the spring season. The results were so uniformly distributed it was felt that they were of little water quality significance. The sodium ranged between 11.4 and 13.4 mg/l for the overall lake. The potassium range was between 1.4 and 2.1 mg/l for the entire lake.

Dissolved Solids, spring season

western sector average - 165 mg/l
central sector average - 190 mg/l
eastern sector average - 170 mg/l

Dissolved Solids, summer season

western sector average - 190 mg/l
central sector average - 190 mg/l
eastern sector average - 195 mg/l

Dissolved Solids, fall season

western sector average - 180 mg/l
central sector average - 170 mg/l
eastern sector average - 200 mg/l

Biological Findings

Biological sampling consisted of analyses of benthic fauna, phytoplankton, attached algae, chlorophyll, light penetration, and seston.

Benthic Fauna

The benthic fauna of Lake Ontario was comprised principally of seven types of organisms. However, two types, Amphipoda (scuds) and Oligochaeta (sludgeworms), constituted 95 per cent of all organisms collected. The remaining 5 per cent consisted of Sphaeriidae (fingernail clams), Tendipedidae (bloodworms), Isopoda (aquatic sow bugs), Hirudinea (leeches), and Mysidacea (opossum shrimp) in that order of dominance. Amphipoda were the predominant organisms at all stations in the lake except Station 10. This station is located approximately five miles northeast of the Niagara River outlet. The predominant organisms at Station 10 were Oligochaeta, which

comprised 95 per cent of the total number of organisms per square meter. The remaining 5 per cent were fingernail clams, scuds, and bloodworms.

The ranges in number of organisms per square meter varied from 0 to 5400, of which scuds and sludgeworms comprised approximately 72 per cent and 23 per cent, respectively, at all deep water stations, except Station 10, and during all phases of sampling.

A difference in bottom fauna does exist between the lake proper and the major harbor areas, such as the Niagara River, Genesee River, and the Oswego River harbors. The absence of clean water organisms and the presence of a greater number of pollution-tolerant organisms indicated that these rivers do contribute to the degradation of the water quality in these areas.

Phytoplankton

The densities of phytoplankton in Lake Ontario ranged from a minimum of 50 organisms per ml to a maximum of 3600 organisms per ml in 1965. Although total numbers of phytoplankton in this range indicate moderate biological activity, the type of algae present is very important. In May of 1965, the total counts were greater than in July or September. These counts consisted predominantly of the green alga Scenedesmus, indicating a Spring pulse. During the July and September sampling seasons, the predominant form identified was Chlamydomonas, a flagellated green alga. Both Scenedesmus and Chlamydomonas are indicative of nutrient enrichment and are not found as dominant forms in the other Great Lakes, except Lake Erie.

Chlorophyll analyses during these seasons revealed a higher photosynthetic activity during the summer and fall than in the spring, due to the greater intensity of sunlight, length of day, and change in predominant organisms. The types of phytoplankton present in the summer and fall were large cell green algae, capable of containing more chlorophyll per unit volume than the algae found in the spring.

Extended-range plankton analyses of the other Great Lakes, except Lake Erie, reveal that they are dominated by diatoms, a group of algae generally associated with clean water and streams of low nutrient values. In Lake Ontario, green algae were predominant, indicating organic enrichment. The source of this enrichment is due primarily to the large influx of nutrients from the Niagara River and other major tributaries and wastes discharging into Lake Ontario.

When inorganic nitrogen concentrations exceed 0.3 mg/l and soluble phosphates exceed 0.03 mg/l, along with favorable chemical and physical conditions, i.e., light, temperature, turbidity, trace elements, and vitamins, conditions can exist to produce algal blooms.

Nitrate and phosphate concentrations in Lake Ontario, as discussed under chemical findings in this report, are sufficient to support algal blooms

throughout the lake. On July 23, 1965, a bloom occurred which covered the entire deep-water area, beginning about ten miles from both the United States and Canadian shores and extending from the eastern to the western end of the lake. It was identified as Anabaena, a filamentous blue-green alga associated with high nutrient levels. The bloom appeared as a blue-green film on the surface of the water and counts averaged 10,000 organisms per milliliter.

Attached Algae

In July of 1965, visual observations were made to determine the extent of Cladophora growth along the United States shoreline. Cladophora, a filamentous green alga, is found in areas where the bottom is generally rocky and shallow, and wave action occurs. Lake Ontario affords an excellent substrate for algal attachment. Along the United States shoreline there are approximately 250 square miles of suitable substrate for attachment of Cladophora. Considering the Canadian shoreline, this area would be more than doubled.

Along the entire Lake Ontario shoreline Cladophora flourishes and produces many problems. When it matures, during the summer, it breaks away from the rocks and is carried by the currents to the beach. Here, it is battered by wave action and decaying takes place. Windrows of decaying algae have been noticed at all beaches and problems have occurred with water supply intakes along the lake.

This condition occurs all summer. Beaches and cottage areas have been rendered unsuitable because of obnoxious odor and appearance.

Summary

Evaluation of biological conditions in Lake Ontario shows the lake can be classified as tending to become eutrophic.

The benthic fauna of the lake indicates oligotrophic conditions. However, the phytytoplankton and attached algae problems that occur tend to support a eutrophic nature. The ability of the lake to support algal blooms in the lake and great masses of Cladophora along the littoral zone is a definite indication of eutrophication. The average light penetration value of 5 meters (Secchi Disc) at the extended-range stations is the shallowest of all the Great Lakes, except for Lake Erie, which has an average of 4.5 meters.

Apparently the one major factor that saves Lake Ontario from becoming eutrophic is its deep water.

Microbiological Findings

The microbiological study of the Lake Ontario Basin included tributary mouth, harbor-inshore, and extended range stations. The parameters considered in the study were total coliform, fecal coliform, fecal streptococcus, and total plate counts. All of the tests were run by the membrane filter technique.

The total coliform test is used as an index of all coliform organisms present and does not differentiate those of fecal and non-fecal origin.

The fecal coliform test is a measure of the coliform organisms definitely of fecal origin. This test may be used to indicate the type of pollution and whether or not it is recent, as fecal types have a faster die-off rate in the water environment than those of non-fecal origin.

Fecal streptococcus organisms are all strict parasites of warm-blooded animals and have about the same die-off rate as fecal coliform organisms, but less than some of non-fecal origin. Their main usefulness is to confirm the supposition presented by evidence of coliform organisms.

The total plate count is a supplemental test which uses a nutrient media that is conducive to the growth of a great number of bacterial types, including those of natural waters and the intestines. Plate counts at 20°C give an estimate of heterotrophic bacteria in natural waters. Plate counts at 35°C are indicative of heterotrophic organisms of pollutional origin.

The following paragraphs give the results of the tributary mouth, harbor-inshore, and extended range sampling.

Tributary Mouth and Harbor-Inshore

Western Sector - The western sector has two tributary mouths: the Niagara River, which had total coliform averages of 640 per 100 ml (milliliters), and Eighteen Mile Creek, which averaged 1,030 coliforms per ml. The harbor-inshore stations in the immediate surrounding area of the Niagara River showed averages as high, or slightly higher than, the tributary mouth station. The rest of the harbor-inshore stations in the western sector averaged below 300 coliforms per 100 ml. Fecal streptococcus results were generally consistent with total coliform values.

Central Sector - The central sector has many small streams and creeks, along with a sizable river, the Genesee. Three tributary mouth stations in the area showed coliform averages over 1000 coliforms per 100 ml. They are: Johnson Creek, with 1,300 coliforms per 100 ml; Salmon Creek, with 1,100 coliforms per 100 ml; and the Genesee River, with 2,900 coliforms per 100 ml. All harbor and inshore stations west of the Rochester harbor stations averaged less than 250 coliforms per 100 ml, with correspondingly low fecal streptococcus numbers.

The Rochester harbor stations, excluding Irondequoit Bay, indicated significantly higher pollutional loading. The total coliform numbers for these

stations averaged 1,200 per 100 ml, but fecal streptococcus numbers were low and seemed to have no correlation with high coliform counts. The Irondequoit Bay stations showed little pollution, with total coliforms averaging 100 per 100 ml and fecal streptococcus organisms averaging 6 per 100 ml.

The central sector harbor-inshore stations to the east of the Rochester harbor had somewhat lower coliform averages of 940 per 100 ml and fecal streptococcus averages of 37 per 100 ml. The high counts in this area were generally downflow from the Rochester harbor.

Eastern Sector - The eastern sector is under the influence of several large streams, the Oswego and Black Rivers, and many smaller tributaries. Three of the tributary mouth stations gave average total coliform numbers over 1000 per 100 ml: the Oswego River with 1,600 per 100 ml, the Salmon River with 1,900 per 100 ml, and the Black River with 3,200 per 100 ml. Fecal streptococcus all were well over 100 per 100 ml.

The harbor-inshore stations west of the Oswego harbor had little pollution, with total coliforms averaging 100 per 100 ml and fecal streptococcus organisms averaging 5 per 100 ml. The Oswego harbor stations, although evidencing higher coliform counts, were not unduly high, except for a few stations in close proximity to the mouth of the Oswego River. Their averages were 260 per 100 ml and fecal streptococcus averaged 13 per 100 ml. Stations east of the Oswego harbor gave little evidence of fecal pollution away from the tributary mouths. Total coliform numbers were 80 per 100 ml and fecal streptococcus averaged 8 per 100 ml.

Extended Range

Western Sector - The western sector, as a whole, had the highest total plate counts, but did not have high total coliform counts, except for a very slight increase in the mid-summer cruise.

Both total plate counts and total coliform counts were low in the western sector lake stations. The 20°C, or non-pollutional, plate counts were higher than the 35°C, or pollution-indicating, plates.

Total coliform counts for the western sector were low, many stations having none. A few, however, were in the 500/100 ml range. Their numbers increased very little from the spring to mid-summer cruises, and their greatest concentrations were immediately in the vicinity of flow from Toronto and the Niagara River.

Central Sector - The central sector had the best waters of the three, but the southern portion, or the United States side, of the lake showed the higher numbers of total coliforms and total bacteria.

Again, the 20°C plate counts were higher than the 35° plates, with a random mixing throughout the depths. A general in crease in both types was

noticed in the mid-summer cruise. The highest total plate counts were in the vicinity of Rochester, and there appeared to be some diffusion of these high counts out in the lake to the northeast.

The total coliform counts were very low, some stations recording none on the spring cruise. There was a small increase in the mid-summer cruise and a generally greater increase at Station 23 outside and downflow from Rochester, where the surface sample was in the range of 500 coliforms per 100 ml.

Eastern Sector - The eastern sector again showed higher bacterial values, especially in the southeast area. The total plate counts indicated a greater amount of 20°C non-pollutional organisms than 35°C pollution-indicating organisms in both the spring and mid-summer cruises.

Total coliform counts were low on both cruises in the eastern sector of the lake, ranging from zero, in most instances, to only 100 per 100 ml at Station 41.

Conclusions

Although certain tributaries of Lake Ontario introduce fairly high quantities of polluted water, the main body of the lake at the present time is not to be considered a bacterially contaminated water. As the tributaries enter the lake, their waters mix and dissipate the pollutional load with the lake and, except for harbor-inshore stations in close proximity to or downflow of the tributaries, the quality remains good.

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[illegible]

[illegible]

[illegible]

[illegible] after the lakes, their water [illegible]

[illegible]

TABLE 6-1

SEASONAL AND GEOGRAPHICAL DISTRIBUTION OF DISSOLVED OXYGEN
LAKE ONTARIO - Concentration Ranges Expressed in mg/l

	Western Sector	Central Sector	Eastern Sector
Spring	12.3 - 15.2	11.6 - 14.2	13.2 - 14.4
Summer	8.5 - 13.0	8.7 - 13.4	7.1 - 13.1
Fall	9.9 - 16.5	7.8 - 13.5	8.9 - 13.3

TABLE 6-2

CHEMICAL RESULTS - LAKE ONTARIO
CRUISE 102 - SPRING

Parameters	Western Sector			Central Sector			Eastern Sector		
	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.
pH	*	8.7	8.0	*	8.5	7.7	*	8.4	7.4
Alkalinity	96	102	89	98	161	91	95	106	92
BOD	*	2.5	<1	*	1.6	<1	*	1.9	<1
COD	8.6	15.0	3.9	6.0	9.4	1.9	6.0	10.0	3.3
NH_3-N	0.06	0.19	0.02	0.06	0.19	0.02	0.07	0.19	0.02
NO_3-N	0.33	0.72	0.16	0.33	0.55	0.03	0.36	0.50	0.25
Organic N	0.29	0.76	0.02	0.24	0.71	0.01	0.20	0.67	0.02
Diss. PO_4	0.05	0.10	0.3	0.04	0.08	0.03	0.04	0.06	0.02

* Results not averaged

TABLE 6-3

CHEMICAL RESULTS - LAKE ONTARIO
CRUISE 103 - SUMMER

Parameters	Western Sector			Central Sector			Eastern Sector		
	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.
pH	*	9.1	7.9	*	9.1	7.8	*	9.2	8.1
Alkalinity	97	108	92	95	105	89	93	97	83
BOD	*	2.4	<1	*	2.0	<1	*	1.7	<1
COD	7.8	12.8	1.8	7.7	18.0	0.40	8.7	11.6	3.5
NH_3-N	0.04	0.12	0.12	0.05	0.42	0.01	0.04	0.16	0.02
NO_3-N	0.28	0.72	0.07	0.21	0.80	0.02	0.28	0.68	0.03
Organic N	0.27	0.48	0.10	0.23	0.80	0.01	0.24	0.71	0.01
Total PO_4	0.03	0.07	0.02	0.04	0.10	0.02	0.04	0.12	0.01
Diss. PO_4	0.02	0.05	0.01	0.02	0.05	0.01	0.04	0.10	0.02

* Results not averaged

TABLE 6-4

CHEMICAL RESULTS - LAKE ONTARIO
CRUISE 104 - FALL

Parameters	Western Sector			Central Sector			Eastern Sector		
	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.
pH	*	9.0	7.9	*	8.8	7.3	*	8.7	7.4
Alkalinity	100	109	90	101	178	87	94	123	71
BOD	*	2.4	<1	*	2.0	<1	*	7.8	<1
COD	8.9	22.5	3.4	5.0	10.5	1.2	7.0	10.5	3.4
NH_3-N	0.08	0.26	0.01	0.07	0.30	0.01	0.05	0.22	0.01
NO_3-N	0.34	0.88	0.12	0.35	0.72	0.01	0.30	0.87	0.09
Organic N	0.23	0.44	0.01	0.21	0.49	0.01	0.18	0.32	0.01
Total PO_4	0.04	0.02	0.08	0.04	0.15	0.02	0.04	0.10	0.02
Diss. PO_4	0.04	0.01	0.07	0.04	0.11	0.01	0.04	0.10	0.01

* Results not averaged

CHAPTER 7

WATER QUALITY IN TRIBUTARIES

Niagara Area

The Niagara River contributes 80 to 85 per cent of the total flow input to Lake Ontario and, as such, its quality has a significant effect on Lake Ontario. Detriment to the Lake is evidenced by the biological findings at the mouth of the River which indicated a predominance of pollution-tolerant organisms.

The River is the recipient of poorly treated waste from Buffalo, Niagara Falls, and Tonawanda. The three plants in these areas serve 1,200,000 people. The facilities at Buffalo and Tonawanda are primary plants. The Niagara Falls plant operates at somewhat less than an average primary plant; it receives a loading of 483,000 PE but serves only 110,000.

The amount of industrial waste discharged directly or indirectly to the Niagara River is known to be astronomical. Data on waste volume and concentration for those industries in the Buffalo area is not available and in the Niagara Falls area, it is incomplete. Some idea is gained of the magnitude of the problem, however, when it is shown that the total industrial water usage for the area is over 1,000 MGD. At Niagara Falls it is known that five industries, Hooker Chemical, International Paper, Olin Mathieson, DuPont, and Union Carbide discharge a combined untreated waste of 37 MGD through a diversion sewer. The total PE of this discharge is estimated to be well over 300,000. This discharge, also replete in chlorides, acids, alkalies, cyanides, suspended solids, phenols, dyes, and other chemical by-products, often causes obnoxious odors that permeate the tourist areas at the Falls. In a study of the odor problem by the Buffalo Unit of the International Joint Commission in 1964, it was found that strong pungent chemical and septic odors frequently engulf the gorge area, especially in the vicinity of the American "Maid of the Mist" dock. The report concluded the cause of the odor problem was two-fold; the waters of the diversion sewer and the air pollution that is drawn into the gorge.

Lockport Area

Eighteen Mile Creek, the only sizeable tributary to Lake Ontario in the hundred miles of shoreline between the Niagara and the Genesee River is a grossly polluted stream. The recipient of toxic industrial chemicals and poorly treated domestic waste from the highly industrial Lockport area, this stream is in an extremely degraded condition.

The Creek is in a state of biological inactivity. From Lockport to the dam just above Burt even sludge worms were found in extremely low numbers. Below the dam the Creek begins to recover and both pollution-tolerant and

non-pollution-tolerant algae thrive. A wide variety of benthic organisms begin to occur at Burt, including both clean water and pollution-tolerant forms suggesting a highly enriched environment. A study in 1963 found the stream to be almost devoid of oxygen for a six mile stretch below Lockport. Five-day BODs ranged from 22 mg/l immediately below the City to 10 mg/l eight miles downstream.

Industrial discharges to the Creek are both high in organic and toxic metals. Flintkote Company and United Board and Carton of Lockport manufacturers of paper products discharge a raw waste with an organic loading equivalent to nearly 48,000 people. This is almost one and one-half times the 33,500 population of the entire watershed. Harrison Radiator Division of General Motors, after oil separation, discharges 1,500 pounds of zinc, 280 pounds of copper and 200 pounds of fluoride per day to Eighteen Mile Creek.

Three other chemical producers discharge an assortment of harmful wastes, including cyanides, spent acids, and scrubbing alkalies - nearly all untreated. The primary treatment plant at Lockport discharges a PE of 25,000.

Rochester Area

Lower Genesee River

The lower Genesee River, a twelve mile stretch of river below its confluence with the Barge Canal, is grossly polluted. As the River traverses the City of Rochester some thirty overflows from combined sewers discharge to the River. The discharge occurs continually at a number of locations and periodically at other stations when the flow in the combined sewers exceeds two and a half times the dry weather flow. Four overflows have chlorination.

The Eastman Kodak Park works is by far the main polluter to the River. Despite good primary treatment of a flow that includes waste from a paper plant, a gelatin plant, and a chemical processing works, their effluent is still equivalent to that from a 330,000 population in terms of organic loading. The waste also includes high concentrations of chromium, copper, cyanides, and phenols. Rochester Gas and Electric Corporation adds greatly to the suspended solids concentration in the River by discharging tons of fly ash.

Data collected this past year disclosed zero oxygen zones in the lower three to four miles and five-day BOD's of 25 to 30 mg/l. Fish kills have often taken place in this stretch of the River. The River recovers somewhat only after it mixe with Lake Ontario water.

Rochester Embayment

The Lake waters in the vicinity of the Rochester Embayment are polluted. High coliform and fecal streptococci counts are common; plumes of sewage

solids emanating from the Rochester Sewage Treatment Plant outfall float on the surface; and high turbidities are common both because of the waste loadings and erosion in the Genesee drainage area.

In special beach studies conducted by this Department during the summer of 1965 and since May of 1966, preliminary data indicates that beaches under certain conditions experience high bacteria counts. The high counts are associated with northerly and northeasterly winds and lake turbulence. Table 7-1 gives a general idea of coliform densities for 1965 and 1966.

During the summer of 1965 unusual amounts of floating solids were observed in the vicinity of the Rochester Treatment Plant Outfall. Investigation revealed poor settling capacities and bypassing of great quantities of suspended sewage solids at the sewage treatment plant. Aerial photos from above the outfall location continue to show a milky-colored sewage plume - or waste being dispersed offshore in the Rochester Embayment.

Irondequoit Bay

Irondequoit Bay, a three square mile inlet of Lake Ontario to the east and north of Rochester, is considered to be heavily polluted. The Bay is over-fertilized by nutrients and, because of this, propagates large periodic growths of algae. Most of the algae is of the nuisance type and eventually die off, causing large deposits of oxygen-demanding material on the bottom of the Bay. The small outlet to Lake Ontario, three to 4 feet deep, does not allow a free exchange of Lake and Bay waters. This restriction on flow, the redepositing of the organic matter, plus other related factors to the Bay, tend to retain the nutrients in the Bay area.

Discharged to the Bay, along the shoreline or directly, or via Irondequoit Creek, is the treated (secondary) waste from over 100,000 population. The Bay is the only drainage basin to Lake Ontario where all sewage treatment plants have secondary treatment.

Dissolved oxygen levels in the Bay were found to be relatively high near the surface but declined to zero when depths of 20 feet were reached. Nutrients for plant growth were noted in the Bay waters in concentrations of 1 to 2 mg/l for nitrates and 1 to 3 mg/l for phosphates.

Syracuse Area

Onondaga Lake

Perhaps the most serious pollution problem in the Lake Ontario Basin is that existing in Onondaga Lake. Litterally used up, its waters are extremely degraded and, in the south end in particular, the Lake is an ugly eyesore. Its shoreline is covered with rubbish, trash, and black oily sludge and the surface of the water is covered with foul smelling decaying sludge that is churned to the surface with every passing boat.

Table 7-1

COLIFORM DENSITIES - 1965 AND 1966
ROCHESTER AREA BEACHES

	Ontario		Durand-Eastman		Webster	
Year	1965	1966	1965	1966	1965	1966
No. Samples	23	34	11	35	5	19
Coliform/100 ml						
Highest	8,400	14,000	16,000	18,000	5,300	50,000
Median	1,000	220	520	1,100	180	1,400
% Above 1,000/100 ml	52	27	36	51	20	63
% Above 2,400/100 ml	17	21	18	26	20	37

Table 7-2

AVERAGE NITROGEN, PHOSPHATE CONCENTRATIONS
IN THE FINGER LAKES
mg/l

LAKE	NH_3	NO_3	PO_4 TOTAL	PO_4 SOLUBLE
Otisco	0.18	0.32	0.06	0.02
Skaneateles	0.09	0.66	0.02	0.01
Owasco	0.13	0.63	0.03	0.02
Cayuga	0.24	0.80	0.04	0.02
Seneca	0.17	0.46	----	----
Keuka	0.08	0.28	0.04	0.01
Canandaigua	0.08	0.42	0.03	0.02

The Lake is northwest of the City of Syracuse. It is about four square miles in area, with depths ranging between twenty and sixty feet. The main tributaries are four Creeks, Onondaga, Ley, and Harbor Brook (all three of which run through Syracuse), and Nine Mile Creek. The outlet of this Lake flows into the Seneca River, which joins the Oneida River to form the Oswego River which empties into Lake Ontario - a distance totaling about thirty miles.

The Lake has a long record of pollution. In addition to the apparent callous disregard of the area municipalities and industries as to the amount of pollution they impose on the Lake, the situation is aggravated by its natural hydrologic features. It appears from a preliminary analysis that the Lake would be hard pressed to assimilate even highly polished effluents since it has very little flushing action. The detention time for the Lake has been estimated at over 200 days, an extremely long time for this size lake.

Analysis of samples taken in the summer of 1965 indicated a zone of zero dissolved oxygen concentration below the 25 foot depth. In July of 1965 total plankton organism counts per milliter ranged up to 100,000 and consisted almost entirely of hardy pollution-tolerant organisms, euglena and cyclotella. Chlorides ranged between 1,300 and 3,000 mg/l in different parts of the Lake. Undoubtedly, the chloride input by the large Allied Chemical, Solvay Works, is a factor. In a sampling in November of 1965, 4,000 tons/day of chlorides were being discharged by Solvay to the Lake.

The organic content of the Lake is also high. Five-day BOD's averaged 15 mg/l in 1965. This is understandable in view of the fact that the two large Syracuse treatment plants, and Solvay discharged a PE of over 470,000. Overflows from combined sewers are another factor in the high organic content of the Lake (see discussion on combined sewers in Chapter 5).

Vast deposits of both organic and inorganic sediments were found in the Lake in 1965. Cores of the deposits revealed varying layers of black sludge and white clayey material. The result of many years of discharge of calcium and sodium carbonates by Solvay and partially treated waste by Syracuse, these deposits ranged up to ten feet in depth.

Oneida Lake

Oneida Lake is plagued by nuisance weed and excess algal growths resulting from over-fertilization. In addition to being over-fertilized, mostly from the domestic waste of municipalities on or near the south shore, the Lake unfortunately affords the ideal bottom surfaces for an abundant plant growth. The Lake is relatively shallow with only few areas greater than 20 feet in depth.

In a survey this past summer, approximately 20 square miles or one-fourth of the Lake surface was covered by some type of plant growth. At the same time, great masses of odorous sponge-like decaying algae were piled up

on the beaches. Records show that nuisance algae conditions have always been a problem on the Lake, but not to the extent experienced in recent years. A comparison of recent data with that of a study made in 1918 indicates that the suspended organic matter has increased more than five-fold, and that the types of algae have changed from the relatively harmless free diatoms to undesireable blue-greens. In the summer of 1965, nitrate concentrations ranged from 0.15 to 0.30 mg/l and phosphates from 0.2 to greater than 1.0 mg/l.

The main sources of pollution to the Lake are from three Creeks that enter the Lake from the south. It has been estimated that the present population tributary to these Creeks, Chittenango, Canaseraga, and Oneida, is about 85,000 people. In no case is the waste treatment by any of the ten communities comprising this population better than primary.

Oswego River

Formed north of Syracuse by the juncture of the Oneida and Seneca Rivers, the Oswego is a pollution-laden stream that discharges nearly 6,300 cfs annually to Lake Ontario. The Oswego, high in dissolved and suspended organics at its headwaters, receives raw domestic sewage from three communities and untreated industrial wastes from six large and many small industries.

The River exhibits moderate pollution through and below Phoenix and then recovers slightly. At Fulton, the canalized section between two locks is a veritable sewage lagoon. Discharged to the River above and in this section is the raw waste of the Town's 14,000 residents, a large General Foods-Birdseye Division food processing plant, Nestle's, Sealright Container and North End Paper. Together these industries contribute an organic loading equivalent to a population of more than 77,000.

The River receives no respite below Fulton. Just two miles downstream, Armstrong Cork adds another loading without treatment of 44,100 PE. Its discharge has created an unsightly delta of deposits in the River below the outfall. Further downstream, bottom deposits are re-suspended by passing tugs, making the River a foul black waterway as it passes Battle Island State Park. Dissolved oxygen concentrations of 3 to 4 mg/l were found in this stretch in August, 1965. The devastation to the River culminates in the discharge by the City of Oswego of the raw waste from nearly 21,000 people.

Finger Lakes

This discussion of the Finger Lakes Region includes Owasco, Canandaigua, Keuka, Seneca, Cayuga Skaneateles, and Otisco Lakes. Except for some localized pollution at Ithaca, Geneva and Dresden, the quality of the waters in these Lakes is relatively good. Over fertilization is becoming a problem, however, and if these Lakes continue to be maltreated in the manner of Oneida and Onondaga Lakes, they too will become degraded. The purification capacity of all these Lakes is limited by their relatively long detention times.

The major problem on the Lakes is the inadequate sewage disposal systems serving private cottages. Indications are that most of the cottages discharge raw sewage or septic tank effluents directly to the Lakes. At present the only two large concentrated sources of pollution are municipal wastes from the Cities of Ithaca and Geneva. Ithaca provides secondary treatment before discharging its waste to Cayuga Inlet. Geneva provides primary treatment before discharging its waste into the northern end of Seneca Lake.

The most striking feature of the area is the series of north-south valleys that comprise the major portion of the drainage basin. The picturesque Finger Lakes lie in these valleys. Streams cascading over hills surrounding the Lakes have carved out more than 400 gorges and waterfalls, creating a scenic wonderland. The region is readily accessible from many of the large centers of population in the central portion of the State and is developing more and more as a resort area. A rise in the recreational and fishing use of the water is probable.

The Finger Lakes were all sampled extensively in 1965. They all revealed benthic organisms and phytoplankton of the clean water variety except Seneca and Cayuga Lakes. Both of these Lakes are biologically enriched especially at their inlets and outlets. Cayuga Inlet at Ithaca is in a polluted state as revealed by its bottom fauna. Summer populations of sludgeworms averaged 10,000 organisms/sq. meter. Sludgeworm populations dropped rapidly in the Lake. The northern end of Cayuga Lake is also highly fertile due to its shallow water, rooted aquatic vegetation, and warmer temperatures. This area is part of the Montezuma Marsh and contains a wide variety of fish and waterfowl. Catherine Creek at Watkins Glen on Seneca Lake also possessed a fairly high number of sludgeworms (3,600/sq. meter). At the north end, near Geneva, the Lake forms a fairly shallow shelf, conducive to the growth of rooted aquatic vegetation. A variety of both clean water and pollution-tolerant organisms exist on this shelf, thus providing the support for a wide variety of fish life.

Phytoplankton populations on both Lakes were fairly uniform throughout their length. These populations were generally of moderate concentrations but were dominated by pollution-tolerant green flagellates and green cocoid algae. Extensive blooms of Anabena have been reported in recent years in the south end of Cayuga and the north end of Seneca.

In terms of their nutrient content all of the Finger Lakes exhibit signs of accelerated aging. Table 7-2 is a summary of the average nitrogen and phosphate results obtained from samples collected in the summer and fall of 1965. Nitrogen and phosphate concentrations are well above the critical requirements for abundant algal growths.

Black River Area

The Black River is in a severely polluted condition. Untreated discharges by nine paper and pulp mills totaling 640,000 PE and another 58,000

PE from communities seriously deteriorate the stream despite the excellent natural assimilative capacity and the high dilution of the River (average flow 3,900 cfs).

An estimated organic loading from a population equivalent to almost 430,000, pollutes the Black River in its lower reach below Carthage. Fifty thousand of this is from municipal discharges. The remaining ninety per cent is contributed by paper and pulp mills, two-thirds of this by the St. Regis Paper Co. at Deferiet. In a sampling of this and other mills in the summer of 1965, the mill's effluent was found to have a devastating effect on the stream. Emerging from a raceway shrouded with a yellowish colored atmosphere, a multi-colored water surface and a deposit ladden bottom, this mill's waste depleted the oxygen resources of the stream for miles downstream. Watertown, currently discharging a raw waste, is presently constructing primary treatment facilities.

At Lyons Falls the River receives an industrial loading from the Georgia Pacific-Gould Division, pulp and paper plant of 221,000 PE. Degradation of the River by this discharge is severe. A joint study by the New York State Department of Health and the National Council for Stream Improvement in August, 1965, found the DO to be about 2.0 mg/l for the entire 30 mile reach of River between Lyons Falls and Carthage except for a short distance downstream of the Beaver River confluence, when the DO rose momemtarily to 4.0 mg/l.

Barge Canal

The waters of the Barge Canal system tributary to Lake Ontario are, in general, of poor quality. At two areas, below Newark and below Seneca Falls and Waterloo, the Canal is seriously polluted. In a Water Quality Control Study of the entire Canal System in 1963 to 1964 by the Public Health Service, it was determined that 315 municipal and industrial waste discharges impose an organic loading on the Canal equivalent to 6,000,000 people. More than five-sixths of this was attributed to industrial discharges. Only 27 per cent of the 315 sources were known to have received any treatment.

Seneca Falls-Waterloo Area

Known as the Cayuga-Seneca Section of the Barge Canal, this thirteen mile length of stream is extremely polluted. Many fish kills have been reported near Seneca Falls; of note were the kills in October, 1961, September of 1962, and October of 1963.

Data from both October, 1963, and September, 1965, revealed the dissolved oxygen in this stretch dropped from a level of around 10 mg/l at its headwaters at Seneca Lake to consistent lows of 1 to 2 mg/l at Seneca Falls. The cause of this degradation is principally industrial wastes and to a lesser extent the poorly treated municipal waste from the 12,000 residents of Seneca

Falls and Waterloo. Evans Chemetics with a PE of 61,000 and Home Style Foods (partially treated in the Waterloo treatment plant) with an estimated effluent equally strong discharge at Waterloo.

Newark Area

Another serious pollution problem exists below Newark. The cause of the pollution is a combination of a lack of industrial waste treatment and unfavorable hydrological features. There is a lock at Newark but no dam for flow regulation. The entire Canal flow is diverted upstream of Newark and carried via Ganargua Creek to a point on the Canal 18 miles downstream of Newark. This in effect creates a stagnant pool downstream of Newark.

An industrial waste survey of the three largest industrial polluters (Edgett and Burnham Cannery, Perfection Canning and Riegel Paper) in the Newark area and an intensive DO survey of the Canal were conducted in the summer of 1965. Dissolved oxygen concentrations dropped from about 8 to 9 mg/l above Newark to zero mg/l about one mile below the industrial discharges at Newark and remained at zero mg/l until Lyons, a distance of about 7 miles. Massive fish kills are reported to have occurred in this pool in August of 1961, October, 1963, and November, 1964.

Newark does have fairly good treatment for its 12,000 residents. It is one of the few secondary treatment plants in the Lake Ontario Basin.

CHAPTER 8

LAKE CURRENTS

Lake Ontario

Oceanographic studies of Lake Ontario were begun in August 1964. Their purpose was to determine the water circulation of the lake, to establish the cause and effect relationships so as to be able to predict the movement of pollutants occurring in, and being discharged into, the lake, and to enable other interested groups to more accurately describe and understand the physical, biological, and chemical phenomena of the lake. To accomplish this, seventeen current-metering stations were set in Lake Ontario. Richardson-type current meters were installed at various depths at each station. The Richardson current meter is a self-contained recording instrument; a clock turns it on periodically (every 30 minutes in this case) whereupon it records directional and speed data for one minute on 16 mm film and then shuts itself off until it again recycles. Temperature recorders were also installed, suspended at depths of 30, 50, 75, 100 and every 100 feet thereafter. A recording anemometer was mounted on an anchored surface buoy, except during the winter months. These stations were in operation for fourteen months from August 1964 to early November 1965. In order to supplement the current data obtained from these seventeen stations, several temporary nearshore stations were also operated.

Description

Lake Ontario is approximately 190 miles long and 53 miles wide. Its greatest depth is 842 feet; the average depth is 300 feet. The total volume of the lake is 391 cubic miles and retention time is on the order of nine years. The surface area of the lake is 7,600 square miles; its basinal area is 34,800 square miles. The lake surface is 246 feet above sea level and its deepest part is 600 feet below sea level. The Niagara River, with an average yearly flow of 205,000 cubic feet per second, is by far the largest river draining into the lake. Mean yearly outflow through the St. Lawrence River is 241,000 cubic feet per second. Net inflow to Lake Ontario from other streams and ground-water sources is on the order of 35,000 cubic feet per second.

Lake Ontario can be divided into two longitudinal basins: one is located almost centrally, with a maximum depth of 630 feet, and the other is at the eastern end of the lake and has a maximum depth of 842 feet. Of the two basins, the shallower one comprises almost two-thirds of the lake and has gently sloping sides. The deeper basin is much more sharply defined. A ridge separates the two basins, with a maximum sill depth of 540 feet.

Factors Governing Water Circulation

Three principal factors govern water circulation: the winds, their velocity and direction; water temperature, as it affects density variations within a water column; and barometric pressure, as regards low and high pressure cells, their direction, areal extent and magnitude. All three factors, winds, barometric pressure, and temperatures are acting on the water mass; however, the dominant factors are the winds occurring over the water surface and the temperature characteristics of the water column. Other factors that act upon the movements generated by the winds, temperatures, and barometric pressure are the harmonic reinforcement or attenuation due to the physical shape of the lake basin and the rotation of the earth, or the Coriolis effect.

Winds

The wind data collected at the current-metering stations shows that the prevailing, or net transport, direction is from the southwest in the summer and fall months. In the winter and spring months data from land stations show a northerly shift in the prevailing winds; the directions are west to northwest. Lake stations near the shore tend to show the effects of onshore and offshore winds, which askews their directional modes. While the direction of net wind agrees well with the prevailing land winds, the total flow directions do not agree well. Winds observed over the lake quite often have no relation to the winds on land. Thus, it would be difficult to predict what the directions of lake currents are solely from shore-based wind stations.

The average wind velocities observed were about 15 miles per hour. The empirical relation between winds and currents observed by previous investigators is that currents travel approximately 45 degrees to the right of the mean wind direction and current velocities are approximately 2 percent of wind velocity. With our data still not completely processed, we find currents to flow approximately 30 degrees to the right of the mean wind direction and current velocities somewhat less than 2 percent of the wind velocity.

Temperatures

Lake Ontario is a dimictic lake having a surface temperature above 56°F. in summer and below 39°F. in winter, a large thermal gradient, and two vertical circulation periods, one in spring and one in fall. In Lake Ontario, heating in the spring from a low temperature, the water becomes divided into an upper layer of warm, readily circulating, and turbulent water called the epilimnion, and a lower layer of cold, and relatively undisturbed water called the hypolimnion. A layer separating the epilimnion and hypolimnion, a region where a rapid temperature change takes place, is called the thermocline.

When the lake is stratified the waters in the hypolimnion (the lower layer) are physically and chemically isolated, the effects of which are that during this period little oxygen replacement takes place in this zone and any chemical or biological system must operate on a reserve supply. Fortunately, in the case of Lake Ontario, 85 percent of the lake's volume is in the hypolimnion (the lower layer). This is not the case in shallow-water lakes, such as Lake Erie, where less than 20 percent of the total volume is contained in the hypolimnion and serious oxygen depletion is common. During this period of stratification the volume of water with which a pollutant could mix is greatly reduced. What may be considered a safe input in the winter months when the lake is essentially isothermal may in summer months be critical, particularly in embayments during periods of quiesence.

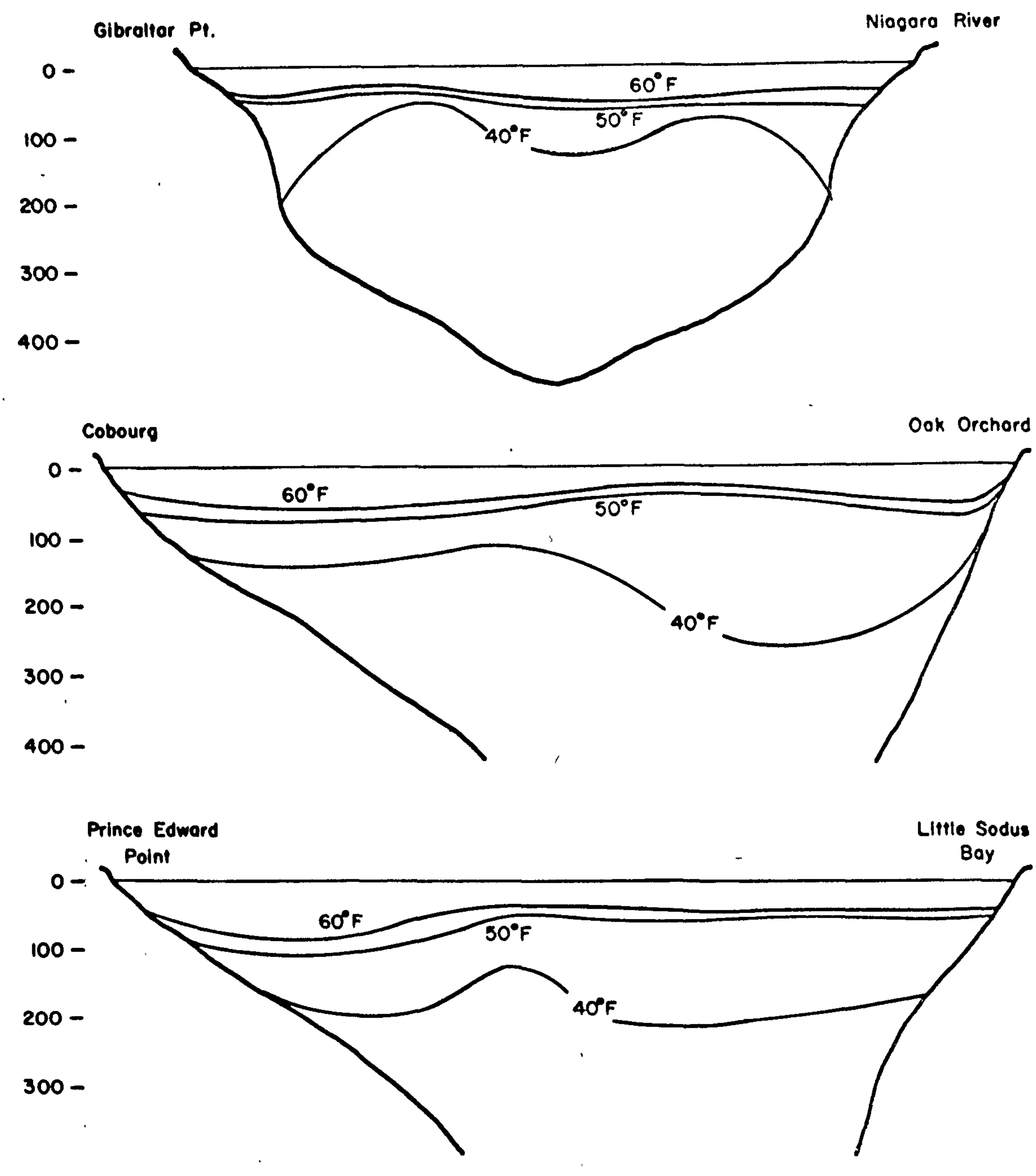
In the winter months the lake again becomes stratified, but the stratification is not as stable nor as pronounced as in summer, so that for practical purposes the lake can be considered to be essentially isothermal. At this time the bottom layer will again be made up of water at maximum density of 39°F., but the surface layer can cool to a temperature below 39°F. Thus, in winter there is at times warmer water at the bottom of the lake and a colder layer at the surface. The period of thermal change between summer and winter conditions is called the "overturn".

The thermocline begins to develop in late May, reaching its maximum development and depth of approximately 75 feet by late August. From September the epilimnion begins to cool until the stratification becomes unstable and overturn occurs, usually in conjunction with a storm. This fall overturn can occur as early as late October; usually, however, it occurs sometime in November. A point to remember here is that while the lake is cooling, the depth to the thermocline tends to become greater.

Figure 8-1 shows three temperature profiles of the lake during the month of August. The isotherms are depressed on both the northern and southern side of the lake and bulged upward in center. This type of thermal structure is what we would expect if the water circulation were counterclockwise; thus, the temperature data, in general, supports the observed summer current-metering data.

During approximately seven months of the year, the water of the Niagara River is warmer and, therefore, less dense than the Lake Ontario water that is below the thermocline. This means that, during this time, Niagara River water mixes only with waters in the epilimnion and that the retention time for Niagara River water is short if compared to what is normally considered the over-all retention time of the lake.

During the spring and sometimes in the fall, when the main body of the lake water is essentially isothermal, a horizontal stratification occurs along the shore line (Figure 8-2). In the spring, the water of the rivers entering the lake is warmer than the lake water (the reverse is true in the fall) and a strong density interface, the "thermal bar",



GREAT LAKES & ILLINOIS RIVER BASINS PROJECT
LAKE ONTARIO PROGRAM

TEMPERATURE PROFILES OF LAKE ONTARIO DURING THE MONTH OF AUGUST

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
GREAT LAKES REGION CHICAGO, ILLINOIS

FIGURE 8-1

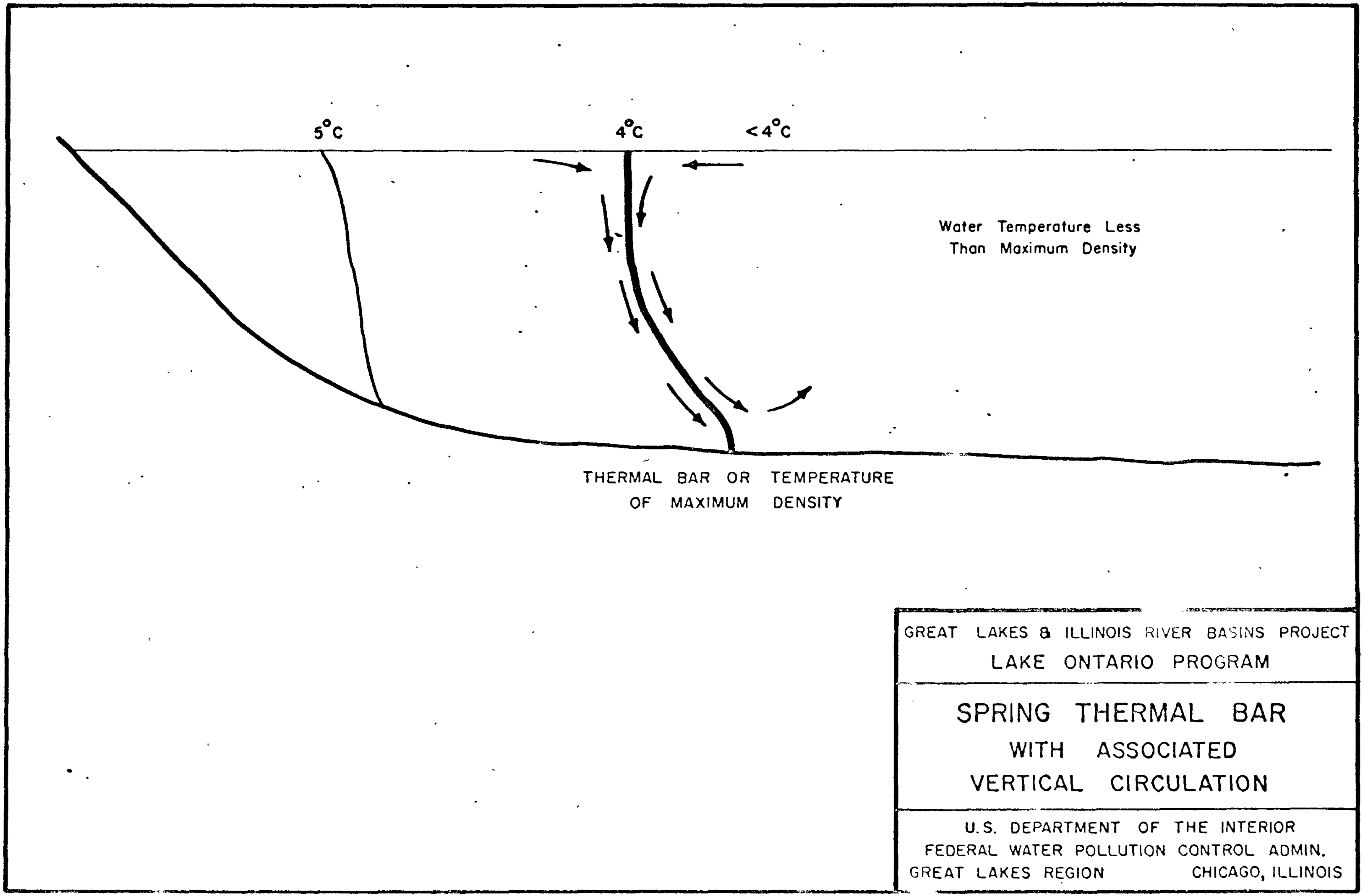

5°C
4°C
<4°C
Water Temperature Less
Than Maximum Density
THERMAL BAR OR TEMPERATURE
OF MAXIMUM DENSITY
GREAT LAKES & ILLINOIS RIVER BASINS PROJECT
LAKE ONTARIO PROGRAM
SPRING THERMAL BAR
WITH ASSOCIATED
VERTICAL CIRCULATION
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
GREAT LAKES REGION
CHICAGO, ILLINOIS

FIGURE 8-2

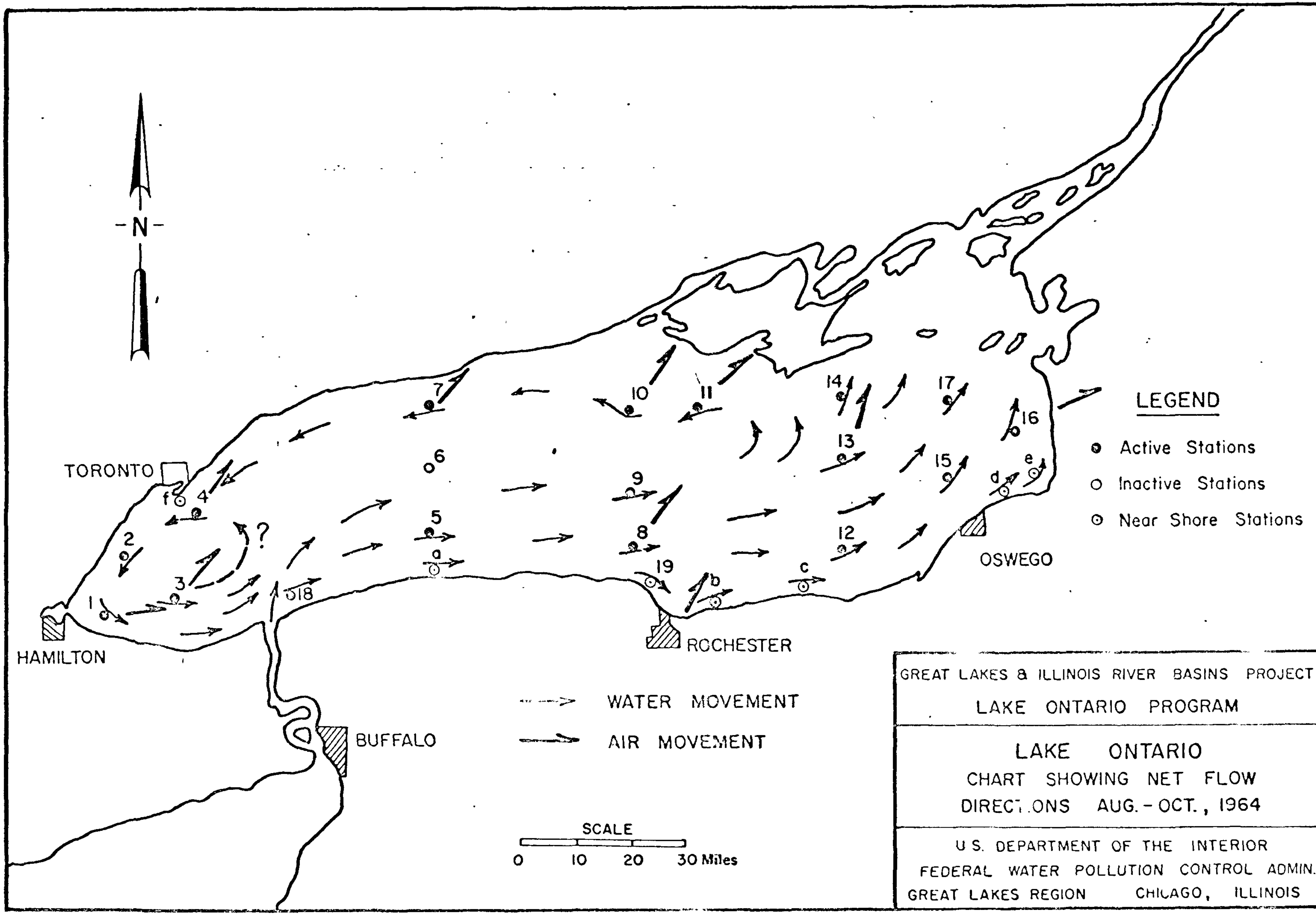
develops at 4°C. isotherm. This thermal bar or interface of maximum density hinders mixing between the two waters. Pollutants discharged into the inshore side of the thermal bar at this time could build up to high levels, particularly in embayments.

Currents

The data collected during the first phase of operation (August to November 1964) show that the net surface flow (Figure 8-3) is well developed toward the east along the southern shore, with a lesser return flow to the west along the northern shore; the return flow originates in the area east of Scotch Bonnet Shoal. The net flow (Figure 8-4) of what can be considered Niagara River water is strongly developed toward the east. There is a suggestion of a gyral occurring in the western end of the lake. If this gyral is there, retention times for any pollutant discharged into this area would naturally be longer and some build-up could occur. In the eastern end of the lake, net flows are generally towards the northeast and are less sharply defined than in the western end of the lake.

Not all of the data from Phase II (November 1964 to May 1965) and Phase III (May 1965 to October 1965) of current-metering operations has been processed, but it appears that the previously-described system of net circulation is associated with the lake being vertically stratified. The counterclockwise circulation in the western end becomes dominant in late June and remains so until sometime in November, which is when fall overturn occurs and the lake becomes essentially isothermal. From late November, the net surface circulation in the western end is eastward, suggesting that upwelling occurs often in this end of the lake. While the fact that the lake is essentially isothermal during this period is important in establishing this system of circulation, the direction of the prevailing winds has shifted and increased in velocity so that the winds are now principally from the northwest, whereas before they were from the west-southwest. That is, the whole net surface flow of the lake is eastward and a bottom return flow is developed westward. Thus, while the previously counterclockwise circulation still exists to some extent, the dominant direction of net surface flow is toward the east and the circulation is verticular, particularly in the western end. In other words, the surface layer in the western end is being displaced to the east, and this water is replaced by deeper water (upwelling). As the surface layer moves eastward it cools and gradually sinks to replace the bottom water that is being displaced westward. At this time, the lake is sort of cleaning its house to have another go at summer. This pattern lasts until the lake again becomes stratified and the winds become more from the south, which is sometime in June.

The average effective velocity (the velocity of net water transport) is approximately 5 cm/sec. The average velocity is on the order of 15 cm/sec. Velocities observed ranged from the starting speed of the current meter, 0.05 cm/sec., to over 50 cm/sec.

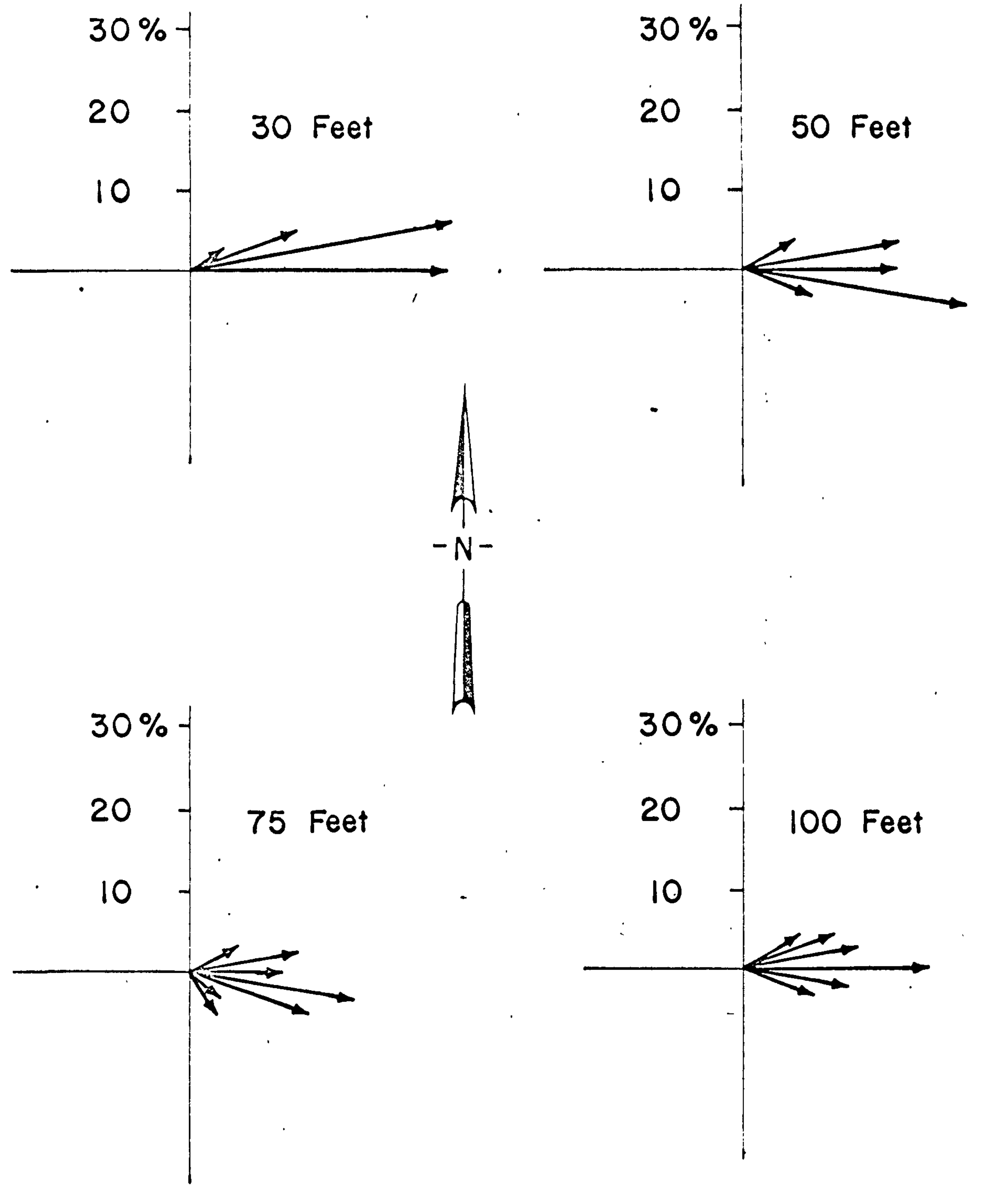


GREAT LAKES & ILLINOIS RIVER BASINS PROJECT
LAKE ONTARIO PROGRAM

LAKE ONTARIO
CHART SHOWING NET FLOW
DIRECTIONS AUG.-OCT., 1964

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
GREAT LAKES REGION CHICAGO, ILLINOIS

FIGURE 8-3



GREAT LAKES & ILLINOIS RIVER BASINS PROJECT

LAKE ONTARIO PROGRAM

POLAR HISTOGRAMS OF STA 18
FOUR MILES N.W. OF NIAGARA RIVER
NET FLOW AUG. TO OCT. 1964

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
GREAT LAKES REGION CHICAGO, ILLINOIS

FIGURE 8-4

Rochester Embayment

Of special interest in water pollution control is the effect that pollution, stemming from several sewer outfalls and the Genesee River, has on bathing beaches and various water intakes within the Rochester Embayment.

Braddock Point to the west and Nine Mile Point to the east form the general limits of the Rochester Embayment. The total area of the Bay is approximately 35 square miles and it contains approximately 8 million cubic feet of water. The average stream flow of the Genesee River, the principal stream discharging into the Bay, is 2,726 cubic feet/sec.

The Lake Ontario Program Office has placed a total of five current-metering stations within the Embayment (Figure 8-5) in order to determine what the water circulation is and how it relates to the winds and the movement of pollutants. Station No. 19, data from which this preliminary report is based, was in operation from November 15, 1964 to December 3, 1964, and was located on the western side of the Embayment near the Monroe County Water Authority's intake at a depth of 45 feet. The other stations were only recently retrieved and data recovered from them. Analysis of these data is now in progress, and results will be available for a later report.

Temperatures

The temperature characteristics of the Rochester Embayment are much like those of the rest of the Lake. Stratification develops in May and lasts until November. During approximately eight months of the year, the water of the Genesee River is warmer and, therefore, less dense than the Embayment waters. This means that during this time Genesee River water will float out on top of the Embayment's surface waters and be in a position to be most readily affected by the winds.

The effluent from the Rochester Sanitary Outfall appears to have a higher temperature than the Embayment waters all year round; thus the effluent will rise and then spread out over the surface where its movement can also be readily affected by the winds.

The important point here is that, while the volume of water moving through a prismatic cross-section of the Embayment, at any one time, is huge compared to the discharge of the Sanitary Outfall and Genesee River, the waters from the Genesee River and the Sanitary Outfall are confined generally to a thin layer on the surface and pollutants can thus be readily transported in any direction about the Embayment by the winds until the polluted layer is mixed with the lake waters and even then throughout the summer months this mixing will occur only in the epilimnion.

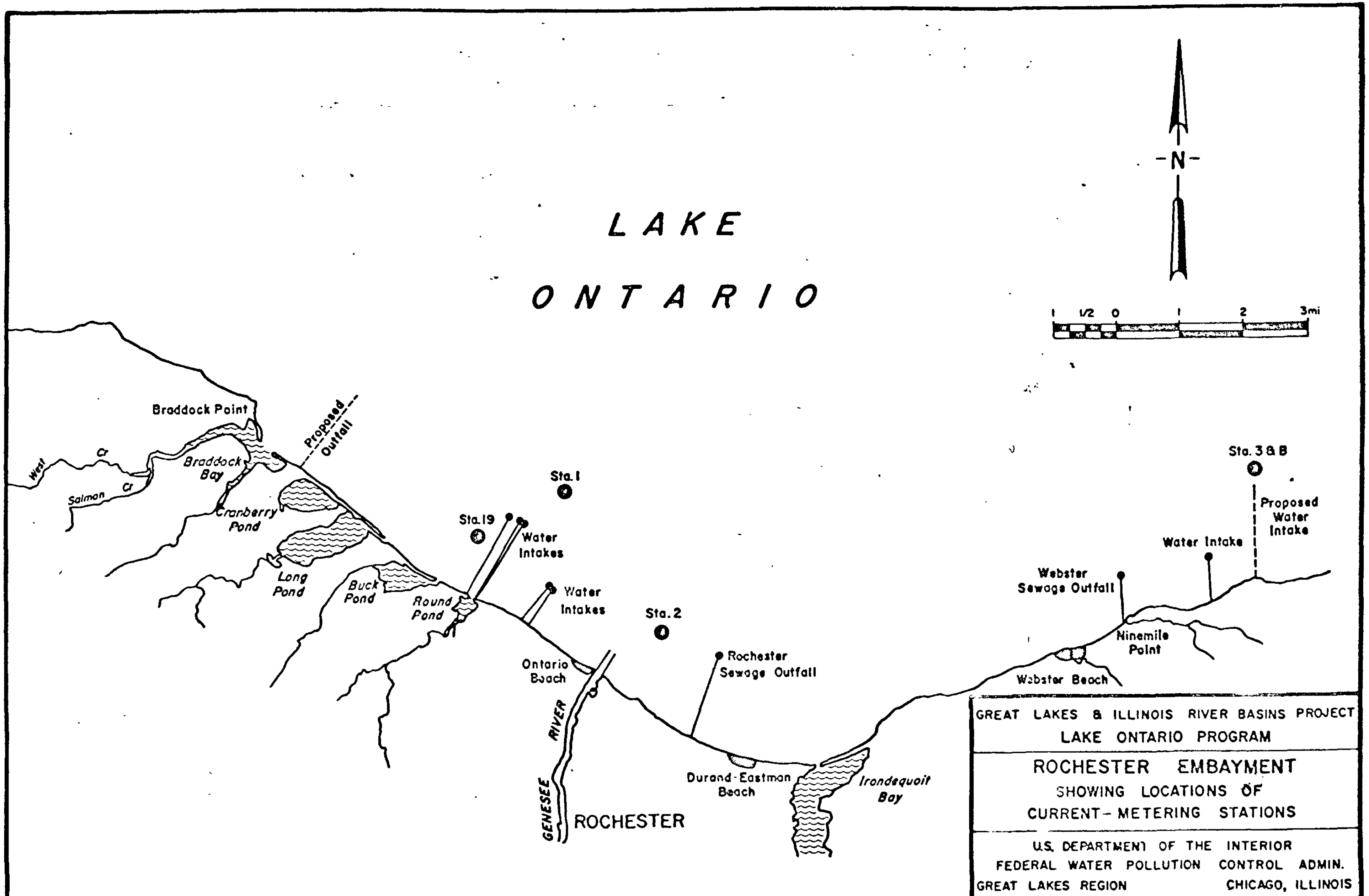

LAKE
ONTARIO
N
1/2 0 1 2 3mi
Braddock Point
Proposed Outfall
West Cr
Salmon Cr
Braddock Bay
Cranberry Pond
Long Pond
Buck Pond
Round Pond
Sta.19
Sta.1
Water Intakes
Water Intakes
Sta.2
Ontario Beach
GENESEE RIVER
ROCHESTER
Rochester Sewage Outfall
Durand-Eastman Beach
Irondequoit Bay
Sta.3 & B
Proposed Water Intake
Water Intake
Webster Sewage Outfall
Ninemile Point
Webster Beach
GREAT LAKES & ILLINOIS RIVER BASINS PROJECT
LAKE ONTARIO PROGRAM
ROCHESTER EMBAYMENT
SHOWING LOCATIONS OF
CURRENT-METERING STATIONS
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
GREAT LAKES REGION
CHICAGO, ILLINOIS

FIGURE 8-5

Currents

There exists a very close relation between wind direction and current direction and wind velocity and current velocity in the Rochester Embayment. The response of the water mass to a change is quite rapid, sometimes it is less than four hours. Except for times when a current reversal was taking place the currents either move in a westerly direction or an easterly direction. When the currents are flowing easterly the flow of the Genesee River and the discharge from the Rochester Sanitary Outfall will be included in this flow. The same holds true when a westerly flow is established. Both the westerly and easterly flow will have a tendency to move inshore,particularly the surface waters.

Winds from the northwest (because of the shape of the Embayment) at times generate a westerly current. As the winds come more from the north the likelihood of a westerly flow increases. Winds from the north and northeast will generate a current flowing westerly. This current is probably the most important as regards pollution to the western beaches and the water intakes in that it has a strong inshore tendency which will more or less slide the surface waters into shore where they can concentrate. Added to this is the fact that winds from these directions will most likely be somewhat higher in velocity than winds from other directions.

Winds from the east and southeast will cause currents to flow westerly, however, this current will tend to move surface waters away from shore. Winds from the west northwest, west, southwest, south, southeast will generate an easterly flow. The current generated by a west northwest to west wind will have a strong inshore tendency; the tendency will be reduced as the wind comes more from the south.

Predictions of current directions based on wind records for a five-year period from the U. S. Coast Guard Station at Rochester, New York, is that currents flowing towards the east will occur 55 percent of the time; currents flowing to the west will occur 35 percent of the time, and 10 percent of the time the currents will be in the process of reversal.

Usually during a period of wind change, say from west to northeast, there is a period of calm at which time the current velocities become quite low. A possible hazard lies in the fact that during this period of quiescence a pool of polluted water could form in the area of the sewer outfall, spreading out on the surface, and then as the wind shifts to the northeast and picks up in velocity the polluted water could be moved rapidly inshore, affecting the bathing areas. A continuing shift in wind conditions and inshore turbulence would break the pool up and move it away. Thus no biological evidence of this pollution would exist, unless a sample was fortuitously taken during this period. Such conditions, as this rapid in and out movement of water could occur in a day or less. Further, if after the sample was tested and it was determined that pollution was serious enough to close the beaches, the

decision would be a day late and the beaches could be closed because of pollution that was no longer existing. To carry it further, if the winds had a periodocity of 24 hours, beaches might be open when pollution existed and closed when no pollution existed. The point here is that an understanding of the relation between wind, currents and bacteriology is needed in order to make intelligent decisions.